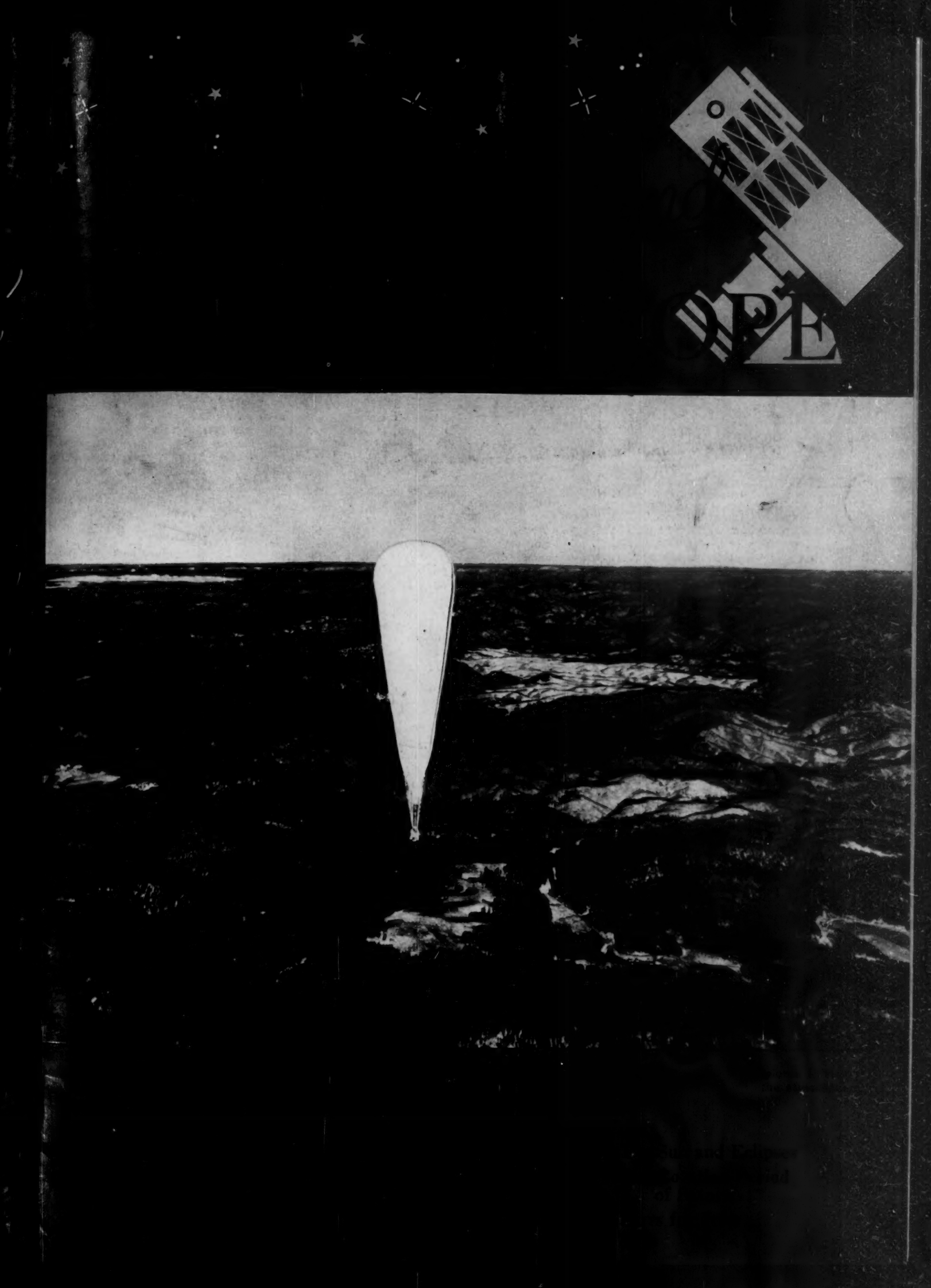
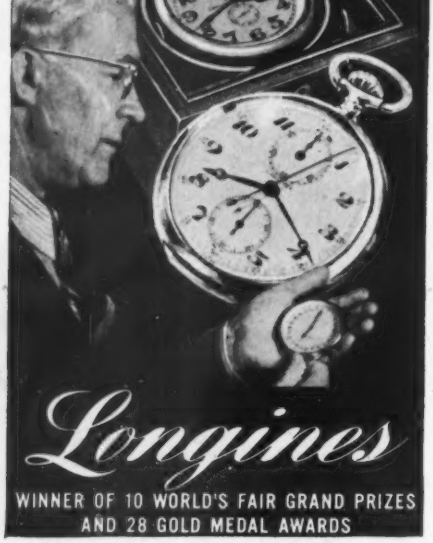


Photograph by William H. Barton, Jr.

THE longest eclipse of the sun in 1200 years occurred in 1937. This awesome celestial spectacle gave scientists a brief opportunity to study the mysterious corona of the sun, visible only during the eclipse. ¶ The Hayden Planetarium-Grace Eclipse Expedition of the American Museum of Natural History went to Peru equipped to make "timing calculations of greater precision than ever before attempted on any eclipse", according to Clyde Fisher, leader. The timing equipment, exclusively Longines, consisted of chronometers, chronographs, and 100th Second Timing Watches. ¶ In 1940, these Longines watches were used by the Hayden Planetarium Eclipse Expedition headed by William H. Barton, Jr. ¶ It is a great honor that Longines watches were selected for these and other scientific expeditions.

*From documents in our files

Longines-Wittnauer Watch Co., Inc., New York, Montreal, Geneva; also makers of the Wittnauer Watch, a companion product of unusual merit.



Sky and TELESCOPE

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The Editors Note . . .

CPL. ROBERT E. COX, whose devotion to this periodical carried it through one of its most trying times, is now in the South Pacific as a meteorologist in the Air Corps. The former New York amateur astronomer and photographer writes, in part:

"Greetings from the South Pacific, from an island upon which French is largely spoken. The stars down here are beautiful. One interesting thing I noticed is that Epsilon Leporis passes directly overhead. I've got my 4¼-inch richest field on a rough, temporary mounting, but all I can see is Jupiter and the moon, as the moonlight blots everything else out.

"En route, no one knew where we were going and stories flew all over the ship. I remembered I had a small protractor and decided to try to make some noon sights and get a position. I mounted the protractor on a board; with Scotch tape and pins I set a plumb line of thread weighted by a piece of metal. After some ineffectual trials I arranged two pins so their shadows would coincide for the sun sight, while the plumb bob registered 90 degrees when I sighted the horizon. I corrected only for the sun's declination and the equation of time on the noon sights.

"Every evening, while it was still light enough to see, I would shoot the pole star for a check; in its place, I shot Canopus when we were below the equator.

"There were two times when I could determine the accuracy of my results: when we crossed the equator and when a plane came out to meet us near our destination. I was about 108 miles off in figuring the first, and 100 miles off in the second. It was a lot of fun doing this crude navigation.

"Every evening I watched the sun set, and once succeeded in observing the 'green flash.' Each night I held star parties up on the bow for anyone interested. I had a group of Red Cross men there regularly and quite a few G.I.'s. I pointed out Orion, the planets, the Southern Cross and the false cross, and we held informal astronomical discussions."

VOL. III, NO. 8 — JUNE, 1944
Whole Number 32

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FRONT COVER: *Explorer II*, the National Geographic-U. S. Army stratosphere balloon, carried two observers and much scientific equipment, including apparatus to study cosmic rays at high altitudes, to a record height of 72,395 feet above sea level. The balloon is here shown rising from the Black Hills of South Dakota, November 11, 1935; fabric and rigging are covered with hoar frost, which later evaporated. The photo was made from an accompanying Army plane by Master Sgt. G. B. Gilbert and Capt. H. K. Baisley, (c) N.G.S., reproduced by special permission from the *National Geographic Magazine*. (See page 7.)

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BACK COVER: A portion of the Milky Way in Cygnus, including part of the Larger Network nebula, NGC 6992, photographed on July 2, 3, 4, 1910, exposure $10^h\ 15^m$, with the 60-inch Mount Wilson reflector. This and NGC 6960 are joined by very faint nebulosity, so that together they form a wreath; parts of this appear to be expanding, indicating that the filaments of nebulosity may be the result of a nova outburst thousands of years ago. Mount Wilson Observatory photograph.

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THE GALACTOCENTRIC SYSTEM

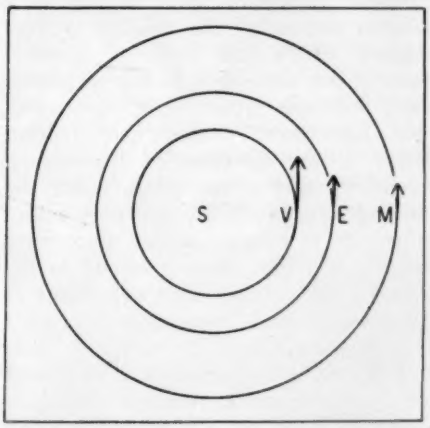
BY PETER VAN DE KAMP, *Sproul Observatory, Swarthmore College*

IT MAY seem strange that it should have taken almost 400 years before the Copernican picture of the solar system (1543) was extended with some success to the Milky Way system. The explanation lies in the spatial magnitude of the latter, which strains our observing methods to the limit, and in the temporal factors which are an even greater strain on the patience of humans, who as individuals are permitted to explore astronomically for such a brief span of time only. The observable motions of the stars are generally very small, and show no curvature; the name "fixed star" has not yet been forgotten! One thing is clear, therefore: if the system of Milky Way stars is in a general state of "Copernican" rotation, the latter must obviously be taking place on a very huge time-scale.

The majestic essence of the Copernican viewpoint of the solar system is the central point of description (the sun), around which a general state of rotation exists for the planets. It is of great interest that this heliocentric conception was arrived at before the invention of the telescope (1610); the application of the latter showed "miniature solar systems," like the Jupiter system with its satellites. Copernicus assumed circular orbits for the planets. Later, the careful observations of Tycho Brahe furnished material from which Kepler derived a more accurate description of these motions; the orbits proved to be ellipses of small eccentricity. That the planetary orbits are not quite circular, and not exactly in the same plane, does not in the least detract from the general rotation description, just as the restricted moving about of the horses in a merry-go-round does not minimize the general overwhelming state of rotation of which they partake.

In trying to discover the general state of motion in the stellar system, it is as if we were asked to explore the mechanics of the solar system from a limited space-time view provided by some nearby planets. For example, we might study the motion of Venus and Mars for a few hours when these planets are nearest. As seen from the sun, the planets Venus, Earth, and Mars describe orbits of increasing size and with correspondingly increasing periods of revolution. The overwhelming bulk of the sun determines the gravitational space-time behavior of the planets in such a fashion that the orbital velocities decrease (according to Kepler's harmonic law) as we go away from the sun. Thus at the time of our observation Venus is overtaking the earth, while Mars is being overtaken.

A portion of the star cloud in Sagittarius, photographed with Harvard's 24-inch Bruce telescope at Bloemfontein, South Africa. The bright stars are Delta (left) and Gamma Sagittarii. The camera was pointed toward galactic latitude —6°, longitude 327°, not far from the direction of the galactic center.



"Shearing" effects when planets are close together in orbits of different sizes.

That the orbits are not exactly circular but slightly elliptical does not change this fundamental *shearing effect* of the state of rotation as a whole, but it does introduce slight additional effects which reveal themselves mainly as a to-and-fro motion along the general direction of the sun.

This may be further illustrated by the following terrestrial analogy suggested by observations made in a railroad station. Assume a number of parallel, horizontal tracks along which trains are running at nearly the same speed. As we look from one of the trains, some of the other trains appear to be slowly overtaken, others to be overtaking our train. If the tracks are still horizontal, but not quite parallel, then there also will be, as we look sideways out of the window, a prominent revelation of approaches and recessions of the other trains with respect to ours. At the same time, this divergence of motions results in a slight general lagging behind, as compared with the case of parallel motions. Slight deviations from the horizontal, for the various tracks, would reveal additional small "up-and-down" effects.

We begin to see now how specific knowledge of the heliocentric picture of planetary orbits might have been obtained by such considerations as provided by the train-track analogy. From a few weeks' observation of the sun's position and diameter, one might have deduced that the motion of the sun is essentially at right angles to the direction of the sun, thus creating the alternative hypothesis of a rotational motion of the earth around the sun. The observed shearing effect, referred to above, would

Harlow Shapley, of Harvard College Observatory.

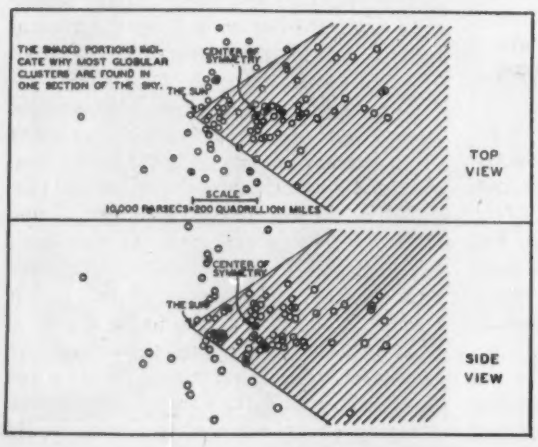
then suggest a general decrease in motion in the spatial tracks as one goes away from the sun. The small to-and-fro effects of Venus and Mars would indicate elliptical orbits rather than circular ones; their "up-and-down" motions would point to slight differences in orientation of the orbital planes. This method of infinitesimal approach was unnecessary for the solar system, but because of the huge time-scale it is at present the only feasible means for studying motions of stars in the galactic system.

Leaving the small-scale study of the solar system for the stellar universe, we remember that it was not until 1718 that the first stellar motions were discovered by Halley. In 1783, Herschel established the motion of our own solar system as a whole, thus putting the sun and stars, from the viewpoint of mechanics, on an equal footing. The law of universal gravitation, put forth at the end of the 17th century by Newton (and in 1915 improved by Einstein), found "universal" confirmation through the discovery by Herschel, in 1803, of orbital motions in double stars, that is, in other cosmical systems than our local solar one. This law describes the universal accelerated falling or gravitational motion of cosmical bodies toward each other, apart from any initial motion of these bodies. The main feature of the law is the diminution of the falling effects inversely proportional to the square of the distances involved; besides this, the bulk or total mass of the bodies is involved.

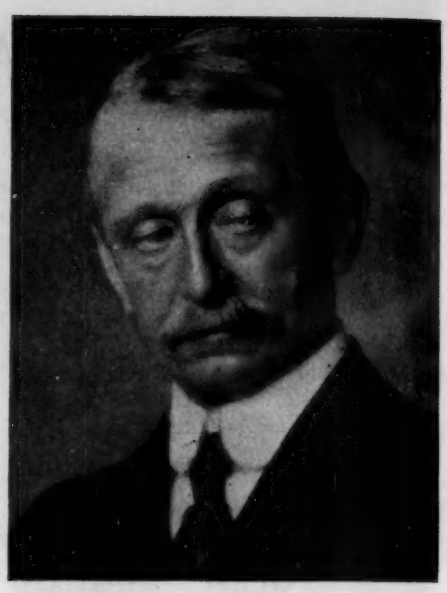
Toward the end of the 18th century, Herschel made the first systematic study of the shape of the Milky Way system based on counts of stars. The result was the now familiar, flattened system whose statistical properties have been a subject of continued study ever since, the principal tools being proper motions, magnitudes, and spectra (Kapteyn and others). As to the location of individual objects, the first stellar distance was measured in 1838 by Bessel. The gradual development of the space-time knowledge of our stellar neighbors was always accompanied by the insistence of the law of gravitation on a unifying description of it all.

In 1904, Kapteyn discovered the existence of a to-and-fro motion, in the sense that although in our neighborhood the stars appear to have velocities in all sorts of directions, there is a definite preference for motion along an axis passing through the Milky Way constellation Sagittarius. Along this preferential arterial direction, traffic, both ways, seems to concentrate. For over 20 years this phenomenon, which has been confirmed for thousands of stars in a wide neighborhood, found no satisfactory explanation. An important advance was made in 1917 from a study of globular clusters. Accepting these objects as a skeleton outline of the galactic system, Shapley placed the bulk of galactic material not anywhere in our neighborhood, but some 30,000 light-years away (one light-year is about six trillion miles) in the direction of Sagittarius. Further progress was made when the sun and stars in our vicinity were found to partake of a large motion, amounting to some 300 kilometers a second in the plane of the Milky Way and about at right angles with respect to Shapley's distant center.

The idea of a galactocentric viewpoint for describing stellar motions, analogous

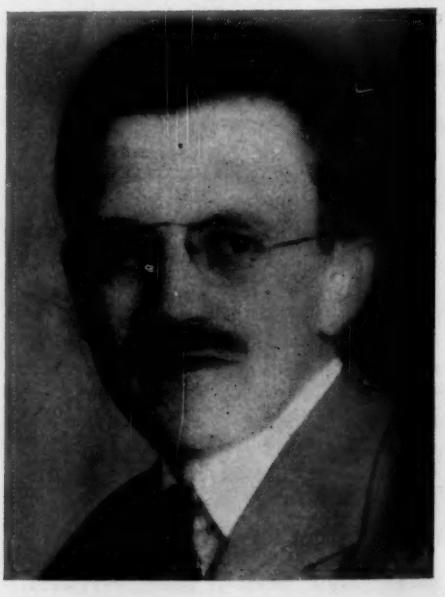


(Left) The space distribution of the globular clusters, which appear to form a more-or-less spheroidal system. The center of this system is assumed to coincide with the center of the galaxy, and the sun is about 30,000 light-years from that center.

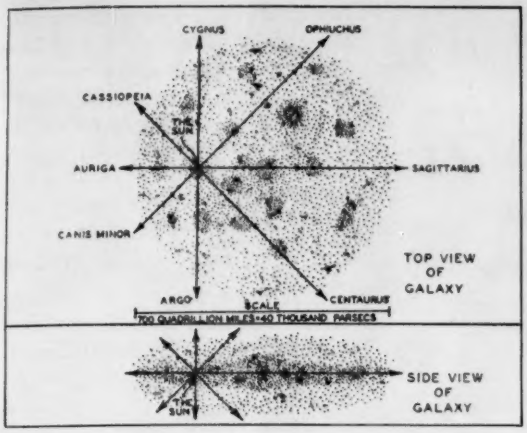


The late J. C. Kapteyn, of the University of Groningen.

to the Copernican heliocentric viewpoint for describing planetary motion, was now ready for development. Several astronomers had established an asymmetrical effect in stellar motion which was exhaustively studied by Stroemberg (1924). About 1926, Lindblad proposed the first successful theory of a state of general rotational motion around the distant center of concentration. The aforementioned asymmetry proved to be the lagging behind of stars whose orbits had appreciable eccentricity. The to-and-fro preferential motion of Kapteyn turned out to be the local revelation of the deviation from "circular" rotational motion for the individual stars describing elliptical orbits of varying eccentricities — while traveling around, some stars were also moving outward, others inward, with respect to the galactic center. The galactocentric orbit of the sun appeared to be of low eccentricity. A year later, Oort discovered the overtaking and being



(Right) Gustav Stroemberg, of Mount Wilson Observatory.



(Right) Bertil Lindblad, of Stockholm Observatory.

(Left) Rough schematic diagrams of the Milky Way galaxy, showing the position of the sun.

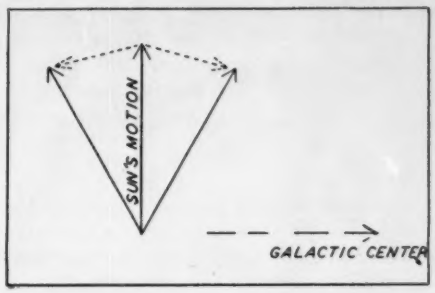
(Below) The heliocentric preferential motion and asymmetry (shown by the dotted arrows) for galactocentric non-circular orbits.

overtaken (shearing effect) for stars nearer to and farther away from the central mass than our sun. There are many additional effects, outside the scope of this article, which are more or less in agreement with the galactocentric viewpoint.

It should be pointed out that apart from the vast space-time dimensions, the progress toward the present goal was for some time halted and is still being obstructed by the haze of obscuring material pervading our galactic system. Originally this gave us the illusion of a central location, but gradually it has turned out to be no more central than a location derived from the restricted vision of a wanderer lost in the forest on a foggy day. Such a limited visibility is egocentric and does not give correct information about the extent of the woods he is lost in. On a stellar scale this has been well realized since 1930, although we have hardly begun to overcome this grave difficulty.

We have, however, an inkling now of the possible state of motion of our Milky Way system. Briefly, the galaxy is a collection of some 100 billion stars of which a large proportion are heavily concentrated toward a location in Sagittarius at a distance of about 30,000 light-years. Except for the globular clusters and certain stars, the general outline of the system is quite flat, say watch-like. It is assumed that the individual stars, including the sun, describe long-period orbits around this distant center; these orbits are ellipses, generally of low eccentricity, and are about in the same plane. The latter is the principal plane of symmetry, the so-called *galactic plane* toward which the general population of stars remains concentrated; thus a state of rotation exists and the general shape of the system, as time goes by, is essentially preserved. From a point of observation within the system, specifically from the sun, various effects are observed in agreement with this description.

Just as the apple falls to the earth at an initial rate of 16 feet a second, the moon is constantly falling to the earth and the planets to the sun at much slower rates. It is of the greatest



significance that this gravitational explanation also should work for the galactic system. Because of the much larger dimensions, the gravitational effects seem gentler, the "falling" motion diminishing according to the square of the distance involved. The sun's orbital velocity amounts to roughly 300 kilometers a second in an essentially circular orbit, with a computed period of revolution of some 200 million years. This figure emphasizes the minute fraction of time during which we have witnessed the galactic rotation so far! For the sun and its planetary family to be kept in this orbital groove, there is required an acceleration toward the distant galactic center of only some eight feet a day! A simple computation

J. H. Oort, of Leiden Observatory.

shows that for our tremendous distance from the galactic center, a central bulk amounting to the equivalent of some 100 billion sun's masses is required to explain this falling effect. This figure is admittedly inaccurate, but the order of size is confirmed by counts of stars, and the galactocentric picture is therefore gravitationally acceptable.

We have thus arrived at a general hypothetical picture having considerable unity. The Copernican heliocentric solar system has found its counterpart in the present galactocentric model of the Milky Way system. In the former, revolving bodies are kept in their orbital tracks by the predominant gravitational falling toward the sun, in the latter, by a similar accelerated motion toward the distant galactic concentration of stars. We need not worry about the continued existence of these models, which seems assured for some time, and may well give our attention to another problem, the origin of these states of rotation, which is still a mystery.

POLARIZED LIGHT FROM M31

Using a polariscope, Dr. Yngve Ohman, Stockholm Observatory, has studied the polarization of light from various parts of the Great Nebula in Andromeda. In three regions of dark nebulosity a marked degree of polarization was found (amounting to from one to six per cent). The observations are applied to the much-debated problem: Which end of the minor axis of the Andromeda nebula is the nearer to us? (See *Sky and Telescope*, No. 28, February, 1944, page 8.)

From a consideration of the amount of polarization and the possible phase angles of the regions in question, Dr. Ohman concludes that the "north-west side of the Andromeda Nebula, containing these dark clouds, is the farther side of the object."

Amateur Astronomers

NEW YORK ANNUAL DINNER

SEVENTY-FIVE members of the Amateur Astronomers Association gathered on April 19th for their 6th annual dinner, marking the 17th anniversary of the society.

Dr. Clement S. Brainin, president, introduced three speakers: John J. O'Neill, science editor of the New York *Herald Tribune;* Dr. Clyde Fisher, honorary curator of the Hayden Planetarium, and founder and first president of the association; and Charles A. Federer, Jr., former secretary of the society, and editor of *Sky and Telescope.* They discussed various aspects of the theme, "Astronomy and Values." Mr. O'Neill pointed out the many cultural advantages of the science; Dr. Fisher described its practical contributions to everyday living; and Mr. Federer viewed the future possibilities of erecting astronomical facilities with the aid of public funds. He also stressed the duty of amateurs to combat astrology actively.

This dinner was equal to its predecessors in the matter of novel entertainment. Several books and other items were raffled; the tickets for the "raffle of the year" were obtained from a desk calendar, and an astronomical event was noted for each date. A new game called *Gegenschein* (née *Guggenheim*) was enjoyed by all; constellation names, star names, astronomers, astronomical instruments, and general astronomical terms provided five classes under the initials S, P, A, C, E. Prizes were awarded for filling in every one of the 25 spaces as well as for the largest total number of words set down.

Perhaps most enjoyable was an Astronomical Fable, devised by Charlotte Malsbary; her ingenuity quite overcame any possible objections from those who do not like puns. The blanks were filled in with astronomical words, the number of dots indicating the number of letters required in each case.

PETER A. LEAVENS

AN ASTRONOMICAL FABLE

If all of you .... will ..... around grandma, she will tell you the story of Mary and Joe.

Now Joe was very fond of pets. He had a ...., a .... and a litter of ..... Each morning he in.....ly went to the park to ..... animals. Joe was also one to ad.... pretty girl so when he saw Mary strolling in the park it was love at first sight.

"Be ..... I'll blow my brains out," he cried.

"Are you really .....?" asked Mary.

"Indeed I am. Can you marry me?"

"Oh yes I .....," she replied.

And so they were married. But wedded bliss is seldom as you ..... Soon there were quarrels. It started with Mary saying that she doesn't like the way ..... his mustache all over the rugs. To which Joe answered that he was always neat. She was the ..... one. Then Mary began to scratch and bite ..... clothes. "You can leave me forever and ..... care!" she shouted. But instead of that, he opened the door and ..... out.

Poor Mary! She tried to earn a living, but there were no jobs so she finally went to the park and just .....ing nothing and thinking of Joe. "I .....zle every night in some saloon," she said to herself. "If I could only wipe out the bitter words that ..... apart!"

She decided to take a last look at their little house and wept with joy when she saw that in the window there ..... throwing out beams to guide her home.

"My darling," cried Joe, "you have ..... last."

And as the picture .....s away, we leave them locked in each other's arms.

(Answers on page 15)

COMET AWARDS

Every year the Donohoe comet medal is awarded by the Astronomical Society of the Pacific for the independent discovery of unexpected comets. This year, five medals have been granted for the discoveries made in 1943; in addition, two belated awards were made for comets discovered in 1942, news of which did not reach this country till September, 1943. The recipients represent a wide geographical distribution: Dr. Vaesaelae, of Turku, Finland; Dr. Fedtke, Koenigsberg, Germany; Miss Oterma, Turku; Mr. Diamaca, Targul Jiu, Romania; Dr. van Gent, Johannesburg, South Africa; Mr. Peltier, Delphos, Ohio (two awards, for his independent discoveries of Comets Diamaca and van Gent).

MADISON AMATEURS ACTIVE

The Madison Astronomical Society continues its activities with the best average attendance ever—in spite of the fact that we have lost some of our most prominent members to the various branches of the armed services.

In planning programs, we do not limit our interests to any one phase of astronomy. Of course, you will recognize Dr. Joel Stebbins, who appeared on our program this spring, the director of Washburn Observatory at the University of Wisconsin, as the recent president of the American Astronomical Society. Dr. C. M. Huffer, who also spoke to us this year, and who is secretary-treasurer of our society, is well known among astronomers. This year we had a fine address by Dr. E. F. Bean, state geologist. Outside of these few professionals, those taking part in our programs year after year have been amateur members of our group. We feel that we benefit in several ways by having most of the addresses prepared and presented by our members.

The June meeting of the society will be on the 14th, and consists of an astronomical quiz program, as well as election of officers.

H. B. PORTERFIELD, president
Madison Astronomical Society

MILWAUKEE ASTRONOMICAL SOCIETY PAMPHLETS

As in former years, the secretary of the Milwaukee Astronomical Society announces the publication of two pamphlets on current celestial phenomena. They are prepared primarily to be distributed by the Milwaukee Public Museum as an accompaniment to the four star maps published by the University of Toronto. One of the mimeographed pamphlets is in the nature of a permanent publication referring to objects outside the solar system which are observable with a small instrument; the other is a guide for the year 1944 and lists current phenomena, positions of planets, and the like.

Sets containing the two pamphlets and the four star maps are sold for the very nominal price of five cents (which is considerably less than cost) by the Museum. A limited distribution of the pamphlets (not the star maps) is being made directly by the secretary, Herbert W. Cornell, 4117 North 15th St., Milwaukee 9, Wis.

THIS MONTH'S LECTURES

Cincinnati: "The Moons of Jupiter" will be the subject of a talk before the Cincinnati Astronomical Association by Dr. Paul Herget, director of the Cincinnati Observatory of the University of Cincinnati. The meeting will be held at the observatory at 8:00 p.m.

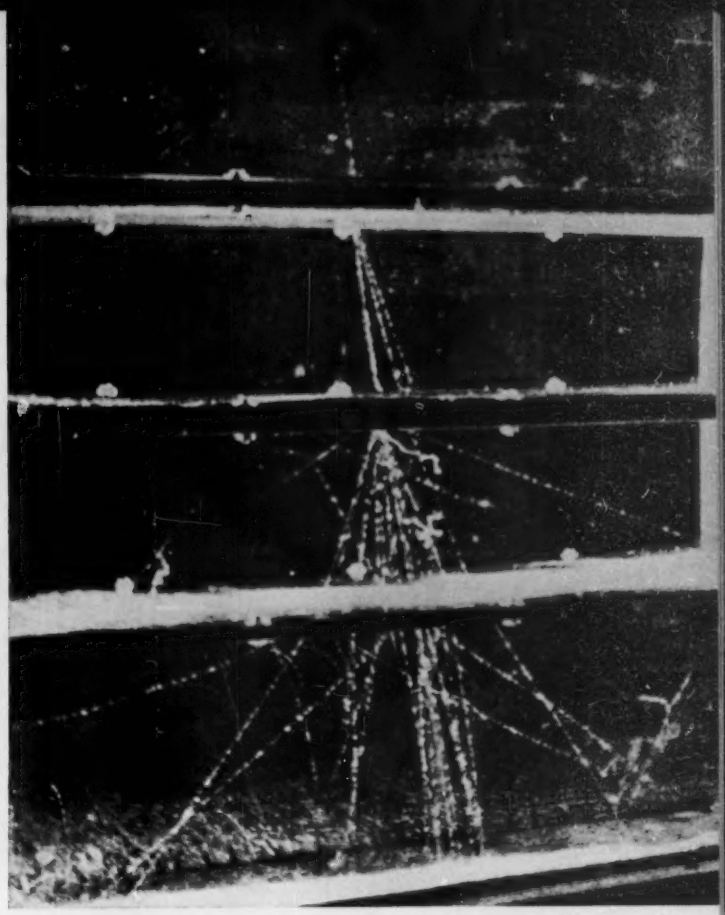
Cleveland: Public nights are announced for June 1st and 2nd, to be held at the Warner and Swasey Observatory. A lecture at 8:30 on "The Summer Sky" will be followed by observing if weather permits. Reservations may be had through the Case School of Applied Science, GArfield 6680.

Detroit: Dr. Hazel Losh, of the department of astronomy at the University of Michigan, will speak to the Detroit Astronomical Society on June 11th; her topic is "The Human Interest Story Behind the Great Star Catalogue." The meeting will be at Wayne University at 3:00 p.m.

The Nature of Cosmic Rays

By W. F. G. Swann

Director, Bartol Research Foundation of The Franklin Institute



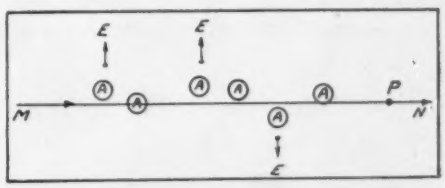
The charged particle shown by the nearly vertical line of dots in the uppermost section strikes a sheet of lead ¼ inch thick. It produces successive generations of progeny in the lead, and these in turn produce more particles as they strike the second and third lead slabs. This is a cloud-chamber photograph taken by Lewis Fussell, Jr.

PART II

3. Activities of the newer atomic particles

TWO DECADES ago, we had only electrons, protons, and photons to think about, and our knowledge of the behavior of charged particles in passing through matter had taught us that such particles lose their energy in the first place by detaching other electrons from the outer structures of the atoms near which they pass. By virtue of their electric charge, their influence extends to some distance on all sides and they, as it were, tickle out participants of the dances going on in the various atoms they approach in their journey. The amount of energy they expend in each act is comparatively small compared with the energy which they possess, but it is much larger towards the end of the path. In fact, a high-energy charged particle, in passing through matter, is like a man with a lot of money in his pocket who, passing through a town with more-or-less regularly spaced saloons, visits each tenth one that he encounters. Then, nearly out of cash, he decides to drown his troubles in more expenditure by visiting the saloons more and more rapidly, until finally he visits every one he encounters, comes to the end of his possessions, goes bankrupt, and departs from the scene of all activities. This characteristic of continually frittering away energy in small amounts is one which is common to all charged particles. Until comparatively recently it was believed, with few exceptions, to be practically the only process by which charged particles lost their energy. These exceptions concerned the production of X-rays and the like; but while important in themselves, they did not account for much of the energy lost by the charged particles. According to the beliefs then current, a photon in passing through matter did nothing at all, except on rare occasions; until, after what was on the average a very long journey, it experienced a direct impact with an atomic electron. To this electron it then communicated the whole or a large part of its energy. Under such conditions, the electron then pursued its path as would any other electron, frittering away its energy by detaching other electrons from molecules.

Now within the last 10 years we have come to realize that something else, very drastic and very important, can happen. The old theories taught us that the higher the energy of the photon the greater its power to penetrate matter. However, both theory and the requirements of experiment began to urge upon us a new picture, a picture in which a photon of very high energy possessed the power to become what I may call "mathematically irritated" on approaching an atom. Under these conditions, moreover, it was able to change its state of existence, to disappear, in fact, and become replaced by a positive and a negative electron which before this event did not exist at all. I am accustomed to cite the analogy of a spiritualistic séance in which the photon is the ghost,



P is a high-energy charged particle pursuing the line of flight MN. It hurls out electrons, E, from many of the atoms which fall near its path.

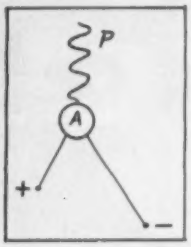
A Summary of the First Installment

THE COSMIC atomic particles, which shoot through each of us at the rate of 10 per second, continually disrupt the atoms of the atmosphere, rendering the air capable of conducting electricity. In 1911, Victor F. Hess found that the destructive power of the cosmic radiation increased with altitude above the surface of the earth, indicating the extraterrestrial origin of the cosmic rays. Further studies showed them to be possessed of extremely great penetrating power, for they were found in deep mines and at the bottoms of lakes. Stratosphere balloons provided measures of cosmic ray intensities as high as 72,000 feet; observations were made in widely separated parts of the world by many workers.

It was apparent that the study of cosmic rays was closely linked with investigations of the fundamental building blocks of physics, which 50 years ago were thought to be the atoms of the 92 elements. Then, with the discovery of the negative electron and the 2,000 times heavier positive proton, all matter was thought composed of these two particles. The activities of the electrons produced electromagnetic radiation (including light), which was considered as consisting of a wave motion, until certain phenomena required that it also have some characteristics of particles. As a result, physicists considered light to be made up of photons, the ghosts of physics, and no new members of the atomic club seemed needed.

More recently, however, studies of atomic phenomena with modern apparatus led to the finding of several other particles: the positron, positive counterpart of the electron; the neutron, equal in mass to the proton but carrying no electric charge; the mesotron, found by cosmic ray studies themselves, possessed of a charge of either sign and 200 times heavier than the electron; the neutrino, which does nothing but own energy.

the positive and negative electrons represent the materialization of the ghost, and the atom is the medium. Nothing happens to the medium except that it gets a fright; and even this fright is symbolized in the atomic problem by certain shiverings, or let us say oscillations, which the atom experiences during the materialization, but which subsequently subside, leaving it in its normal state.

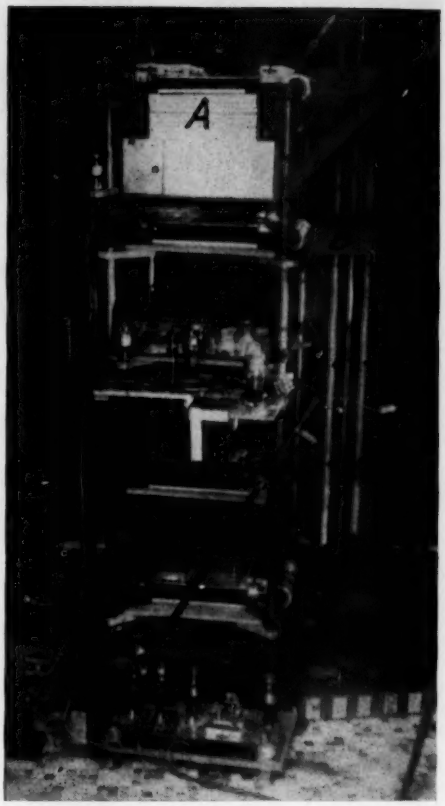


A high-energy photon becomes a positron and an electron when it strikes an atom. These slowly lose energy by ionization, but one may lose nearly all its energy to form a photon that repeats the story.

Then again, the newer views tell us that, in the case of electrons of very high energy, phenomena other than those associated with the slow frittering away of energy to which I have referred become important. One of these high-energy electrons has a great chance of losing a large portion of its energy in the single act of the radiation of a photon as it passes by an atom. These photons, while of smaller energy than the electrons producing them, are still of high energy, however, and again possess the power to become irritated by the atoms which they approach, so that before long each of them materializes into a positive and a negative electron. These then repeat the story through several generations until the energy of the photons and electrons concerned has fallen so low that these more newly discovered phenomena are unimportant.

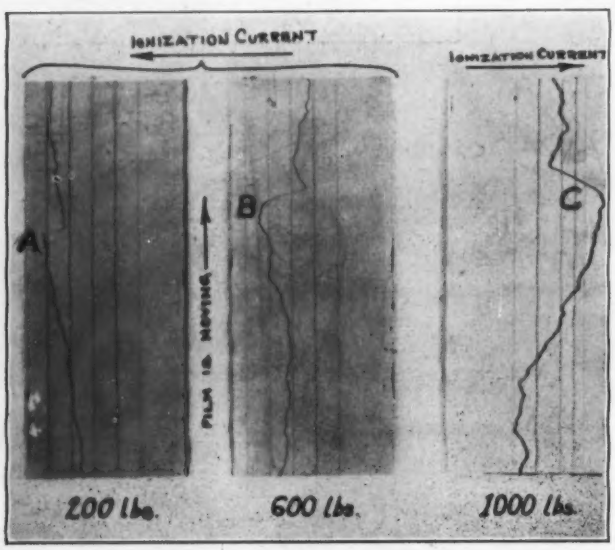
The neutral particle, the neutron, has characteristics quite different from those of the other particles. Being without electric charge, it does not produce the same kind of disruption of the outer structure of atoms and molecules as do charged particles. In fact, the neutron is the radical agitator of atomic physics. While a charged particle has, as it were, feelers extending out from itself in all directions in the shape of lines of electric force, feelers by which the atom becomes aware of its approach some time before it arrives, the uncharged neutron carries no such feelers. The atom does not know the neutron is there until it has already crept into the very nucleus itself, and then the trouble starts. The neutron says (mathematically, of course), "I need a place in the organization." The nucleus replies, again mathematically, "There is no place for you, everything is full up." "Then," says the neutron, "since I am here to stay, we must have a revolution, so that we can create a new atom in which I *can* be accommodated." As the result of all this, the atom blows up, shoots out some of its parts like bullets, in the form of radiations of different kinds, and finally settles down to become a new atom with the neutron a now conservative member of the new organization. The process I have described in these somewhat facetious terms is that by which a neutron, entering an atomic nucleus, causes it to become unstable (as the radium atom is naturally), and so to acquire the property of radioactivity — the property of spontaneous disintegration.

The mesotron is a charged particle. It may be positively or negatively charged, and, as already stated, it is about 200 times heavier than the electron and 10 times lighter than the proton. It is peculiar among all the particles in that it lives for only a short time. A very slowly moving mesotron has what the insurance people would call an expectancy of life of about two millionths of a second. By this, of course, it is not meant that all such slowly moving mesotrons live for the same time; they live *on the average* for two millionths of a second. However, the mesotron is peculiar in another respect. The faster it moves — the greater the energy which it possesses — the longer it lives and the more it gets done in its lifetime. Perhaps in this matter the mesotron will become an inspiration to mankind.



An apparatus used at the Bartol Research Foundation for studying the growth of cosmic ray showers in lead, tin, and so forth. Trays of Geiger counters are arranged in tandem, each covering an area of a little less than a square foot. The apparatus becomes sensitive only when a mesotron excites at least one counter in each tray, in which case every counter traversed by a ray makes a record. Thus, the generation of charged particles in the mass of metal, A, and in other thinner slabs below the various counter trays, can be traced.

The mesotron acts as does any other charged particle in breaking up, ionizing, the molecules of air which it passes in its journey. Sometimes, like the electron, it may come to the end of its useful existence by spending all its wealth of available energy in this way. However, unlike the electron, it may die in harness in the full flower of its activity. The mesotron, like all particles which are heavier than the electron, does not indulge to any appreciable extent in the calling forth of photon ghosts from the atoms near which it passes, and it does not propagate its species through successive generations of photons, as the electron does. It goes on its way doing practically only one thing — ionizing the air — until it either dies in harness or comes to the end of its tether by using up all its energy, and then it waits around doing nothing until death overtakes it. When it dies, it gives birth to



One of the first observed instances of a very large generation of charged particles from a single cosmic ray. The pictures show the continuous record of the ionization current obtained in a long tube filled with air at different pressures. A sudden generation of ions (by a cosmic ray) causes an instantaneous increase in the ionization current, as shown at A, B, and C in the graphs. Results obtained at the Bartol Research Foundation.

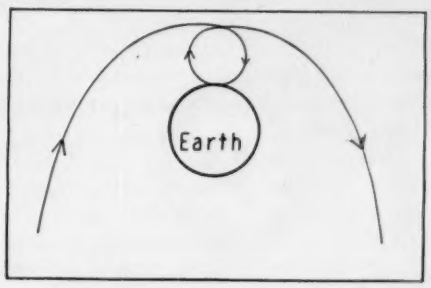
an electron, but a thief, in the shape of the neutrino, is also born and escapes with some of the family goods.

4. Cosmic rays and the atomic particles

NOW, AS I have already implied, in seeking further to understand the activities of the cosmic rays, we should like, if possible, to view them simply as being some of those particles which represent our present stock-in-trade of physics. In his choice between these various particles, the physicist has to proceed by the Biblical instruction: "By their fruits shall ye know them." In arguing the possibilities, he is as one who, standing by a great jagged hole in a wall, hears the remark: "Somebody fired a bullet through the wall." "No," he remarks, "such a large jagged hole could not have been caused by a bullet. That hole must have been caused by a large, slowly moving thing. An elephant is the kind of thing which would have made a hole like that." Or our physicist might be standing by a windowpane with a clean-cut hole right through it, and hear somebody remark: "A careless fellow poked his walking stick through the window." "No," he exclaims, "a walking stick would have shattered the glass completely. Such a clean-cut hole must have been caused by a small thing of high velocity, like a bullet." And so it is by the characteristics of the cosmic rays that we must seek to decide what they are. However, even in this matter the procedure is not as simple as might at first sight be supposed.

At the time when it became reasonably certain that there was some very penetrating radiation of extraterrestrial origin, the only fundamental atomic particles known were negative electrons, protons, and photons. Moreover, our knowledge, even of these entities, was limited to such activities as those in which they had participated in our laboratory experiments. The highest-energy electrons known would only pass through 1/10 of an inch of lead. The most penetrating photons known — the gamma rays from radium — could only pass through two or three inches of lead. Yet the new radiation called for something which could pass through 75 feet of lead, and the protons were even less penetrating than the electrons. The natural thing was to suppose that if the cosmic rays were to be represented at all by electrons or photons, then these entities must be possessed of enormously high energy. And in judging of the expected behavior of the cosmic rays on these grounds, we had to extrapolate over an enormous range (a range comparable, indeed, with a factor of a million in energy) our theories of what was to be expected of electrons and photons when functioning as cosmic rays.

Such an extrapolation was, in the very nature of things, highly speculative. No physicist would be happy about using his experimental knowledge to draw a curve on a piece of blocked paper a square foot in size and then extrapolating the curve from New York to Boston (which corresponds to something like the extrapolation demanded) with the intention of believing the results suggested by the extrapolated curve. It is easy for you to form some concept of the difference between a conventional gangster and a conventional archbishop; but if I

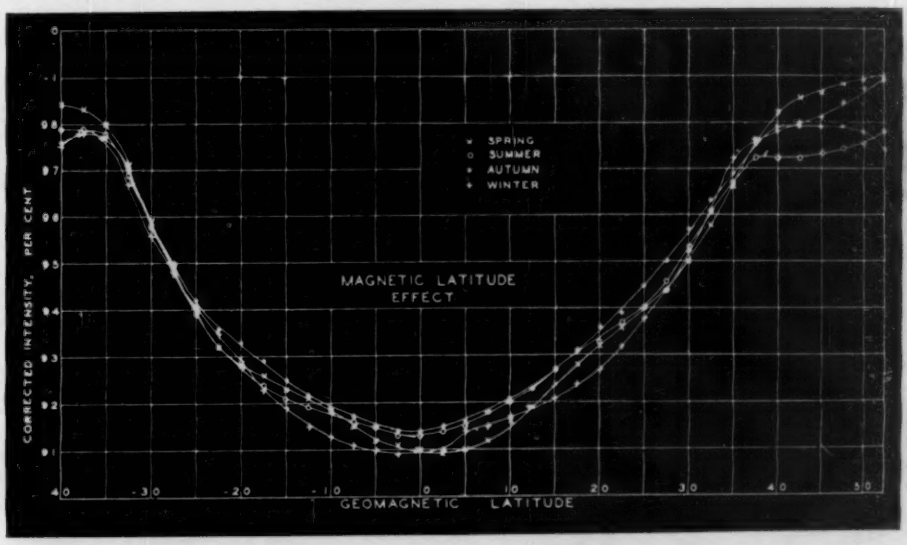


Qualitative picture of the path of a charged particle which just succeeds in reaching the earth at the magnetic equator. The magnetic axis is perpendicular to the paper. By looping the loop, the particle secures the maximum amount of bending in obedience to the earth's magnetic field and, indeed, actually comes back to touch the surface of the earth before it returns to space.

should increase the income of each of these individuals to 10 million dollars per year and endow them with all sorts of other opportunities, it would be a little difficult to predict beforehand in exactly what respects they would then differ. I do not wish to cast any doubts upon the fundamental morality of the archbishop or the fundamental wickedness of the gangster. I do say, however, that in these altered conditions the characteristics of both might be very different from what they are now. And so, even a partial faith in the extrapolation cited above was responsible for many stumbling blocks in our progress toward the understanding of the cosmic rays.

When we first learned of the cosmic rays and of their great penetrating power, it was natural to suppose them to be of the nature of very hard X-rays. In other words, they were regarded as hard photons, for at that time these were the most penetrating things known; we believed that by assuming for the photons a sufficiently short wave length, we could make them as penetrating as we pleased. Charged particles were more or less ruled out for two reasons. In the first place, the energy which the particle would have to possess, in order to provide for all the disruption of atoms it would have to bring about in passing through the atmosphere, is such that more than a billion volts would be necessary to give it that energy. Such energies were regarded as fantastic 20 years ago, although today we do not shudder at energies 10 million times as much. Then another objection came from the expected effect of the earth's magnetism.

The earth is a great magnet, and when a charged particle moves in the vicinity of a magnet its path is bent. The intensity of the earth's magnetic effect at any point is not great, but the extent of the influence is very wide, so that a charged particle coming towards the earth from outside can experience very great bending in its path in traveling distances comparable with the earth's radius. The bending is less, the greater the particle's energy. To illustrate the kind of magnitudes concerned, in the case of an electron approaching the earth in the magnetic equatorial plane, the electron



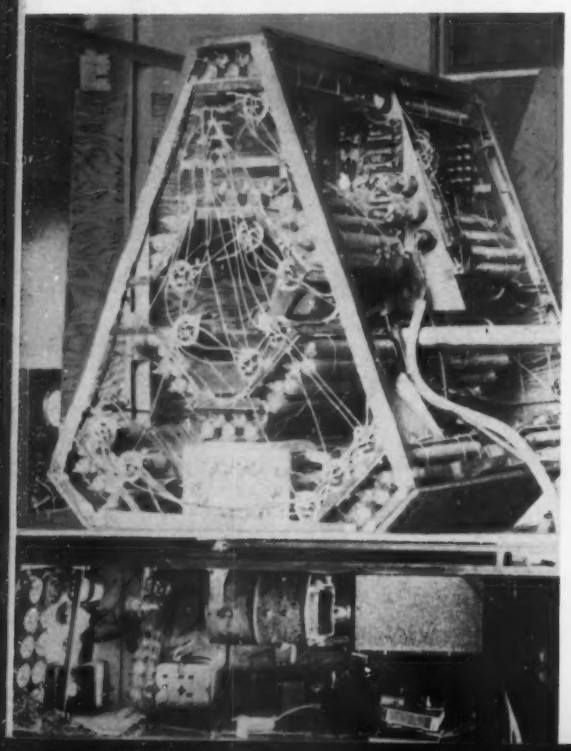
This graph shows the variation of cosmic ray intensity with geomagnetic latitude, after A. H. Compton and R. N. Turner. The geomagnetic equator corresponds only roughly with the geographical equator; the four curves indicate seasonal variations in the corrected observed intensity. Note the "plateaus" beginning near geomagnetic latitudes 40°.

would have to have an energy at least equal to that which would be given to it by 20 billion volts if it were to succeed in reaching the earth at all. If it had less than this, it would be turned back into space.

The drastic effect to be expected from the earth's magnetic field in the case of charged particles led formerly to the belief that if charged particles are responsible for cosmic rays, there should be large variations of cosmic ray intensity with latitude. At that time, no latitude variation was known, and this fact favored the photon hypothesis. Then, when a latitude effect was discovered, and when the variation of intensity with azimuth was observed, these effects, so characteristic of what was to be expected of charged particles, brought the candidacy of these particles once more to the fore. The theory of the effect of the earth's magnetism was pursued more intensely and found to support a belief that the incoming radiation is composed of nothing but charged particles.

In the latitude effect found at sea level, the cosmic ray intensity was a minimum at the magnetic equator and increased gradually as we went towards the poles, until a latitude of about 40° was reached, after which there was no further increase. This behavior was interpreted on the assumption that there was a distribution in energy among the incoming particles, and that at any latitude all particles below a certain limiting energy depending upon the latitude were cut out by the magnetic field. Theory showed that the minimum energy for entry was highest for the equator and decreased towards the poles. The increase of intensity on a journey from the equator towards the poles was attributed to the fact that more and more of the lower-energy particles could get through the field as we proceeded on this journey. The cessation of the increase at 40° was explained by supposing that the minimum energy for entry at 40° was only just sufficient to enable rays with that energy to pass through the atmosphere. Therefore, although the number of rays entering the atmosphere might be expected to continue to increase in the journey towards the poles, all of those rays over and above the rays entering at 40° would have such a low energy that they could not penetrate the atmosphere, and so would be unobserved at sea level.

Apparatus used by T. H. Johnson to observe the latitude effect during an ocean voyage. It consists of a number of Geiger counter telescopes pointed in different directions and arranged to record photographically.



However, with all of this nicely settled, charged particles began to present a difficulty from another angle, for it is obvious that since the rays of least energy entering at 40° could just pass through the atmosphere, all the rays entering at the equator should be able to reach sea level, and we should not expect any increase of intensity with altitude at the equator. Such a result was, however, quite contrary to the facts. It was for this reason that I introduced the hypothesis that the rays, on passing through the atmosphere, shot out low-energy secondary rays to an extent which increased with the energy of the primary rays themselves. Thus, high in the atmosphere, where the primary rays had not yet lost much energy by ionization, more secondary rays were shot out than at lower altitudes. This hypothesis provided for the necessary increase of the measured cosmic ray intensity with altitude at the equator.

It was about this time that the quantum theory of atomic structure predicted this very kind of phenomenon for electrons and gave a more detailed story of its mechanism, the story which I have already sketched, in which the photons, the ghosts, alternate with the material particles, the electrons, in producing successive generations of positive and negative electrons (*pair formation*). Consequently, it was natural to play with the idea that the incoming radiation was composed of electrons. An incoming electron will, on encountering the atmosphere, soon give birth to a photon. The photon, becoming mathematically irritated by its surroundings, soon decides to change its existence and, by itself dying, gives birth to a positive and a negative electron. At first sight, one might suppose that through the creation of successive generations, the number of electrons would increase as we descend into the atmosphere. However, such an expectation is not justified because the progeny are continually losing energy by detaching electrons from molecules — by ionization — and the low-energy progeny come to the end of their tether in this manner. At any point in the atmosphere we should expect, in fact, that there would be a birth rate and a death rate. At first, as we descend from above, the birth rate should be greater than the death rate, so that the number of electrons would increase as we descend. Finally, however, we should expect to reach a place where the birth rate and death rate were equal; and on further descent the death rate would exceed the birth rate, so that the number of rays would diminish with increasing depth in these regions.

Even if a photon were the primary entity entering the atmosphere, it would soon materialize into a positive and a negative electron, and the story would proceed as before. We thus see how, through the agency of this multiplicative process, whether high-energy photons or high-energy electrons were considered the primary agencies which entered the atmosphere, we should have found an increase of cosmic ray intensity as we descended into the atmosphere, followed by a decrease. The actual experimental results of the stratosphere flights, which showed a maximum in the cosmic ray intensity at an altitude of about 11 miles, provided strong confirmation of the theory of the multiplicative process as operative in the atmosphere. Nor have we since found occasion to discard the multiplicative idea, although it has been necessary to modify our conceptions as to the actual primary particles which first enter the atmosphere, and for reasons which will be considered next month.

(*Continued next month*)

PARICUTIN STILL ACTIVE

Slowly creeping lava from Paricutin volcano (see *Sky and Telescope,* February, 1944) is threatening to engulf the town of San Juan Parangaricutirio, nearly five miles away, and to drive 2,500 people from their homes, according to Science Service. Moving six feet an hour, the flow has reached a little valley and this may or may not save the town. The new flow comes from the south side of the volcano, farthest from the threatened town.

Eruption of the volcano itself is at present somewhat subdued, probably due to the effort of ejecting lava; eruptions still occur every nine or 10 seconds.

"Explosions occur very deep within the crater and vapors of explosions issue from the crater's mouth, with noises like waves breaking against a rocky shore," Engineer Ezequiel Ordonez, 77-year-old dean of Mexican geology, told Watson Davis, director of Science Service, in Mexico City recently. Senor Ordonez was trying to arrange government assistance for the Indian population facing eviction by the lava flow.

BEGINNER'S PAGE

Man and His Expanding Universe — VII

By Percy W. Witherell

ON NOVEMBER 7, 1631, Pierre Gassendi observed a transit of Mercury across the sun, thus initiating the problem of the perturbations of this planet in its orbit; the explanation of this phenomenon troubles astronomers of the present day.

Johannes Hevelius, a Polish astronomer, spent many years in his very fine observatory making drawings of the moon in all its phases. He followed the method of Riccioli by using the names of eminent astronomers and philosophers for the more conspicuous features, and classical and geographical names for the more important regions; the designations on the fine maps of Hevelius are the ones in use today.

Christian Huygens (1629-1695) added a pendulum to clocks and designed an improved eyepiece for telescopes. He discovered a ring about Saturn and so cleared up the mystery of the planet's appearance in poorer telescopes. He also discovered a sixth satellite of Saturn. Jean Picard used graduated mountings and micrometers on his telescope, observed the meridian passages of the stars, and determined their right ascensions with a pendulum clock. Ole Roemer measured the velocity of light by observations on the satellites of Jupiter, and was the first to erect a transit telescope.

Giovanni Domenico Cassini is remembered by his discovery of the division in the ring of Saturn and of its satellite, Iapetus. He determined the rotations of Mars and Jupiter, calculated a table of refractions, and explained the librations of the moon.

These varied discoveries by different men illustrate the progress of intellectual freedom in the 17th century.

Let us go back a bit to the early part of the 17th century and consider the effect of the writings of Francis Bacon. He became impatient with the wordy disputes of the philosophers of the past and, proposing that inductive reasoning be applied to actual observations, he asked for the collaboration of men in all branches of learning. In Bacon's opinion, the true function of science is the search for a few fundamental physical laws, whose application should explain the complex as well as the simple observed phenomena. He hoped that, in time, it could be shown that the same physical laws which govern earthly causes and effects are true in the astronomical universe.

Many men had inklings of the truth. As early as 1639, Jeremiah Horrocks thought that the motion of the moon was controlled by the earth's gravity and affected by the sun. Ismael Bouillaud stated, in 1645, that the planetary motions were controlled by a "sun-force" which varied with the inverse square of the distance. Robert Hooke, Edmond Halley, and Sir Christopher Wren had similar beliefs.

It remained for Sir Isaac Newton (1642-1727) to demonstrate mathematically the soundness of this idea. He proved that the law of gravitation applied to the entire known universe and that it explained the movements of all the astronomical bodies. It also applied to the minute particles of matter. It explained the oblate spheroidal form of the earth, as well as the action of the tides, which had puzzled many generations of thinkers.

Newton was a mathematician of the first rank. His invention of *fluxions* (calculus) enabled him to prove that by the law of gravitation the orbit of an astronomical body must be an ellipse, which was in agreement with the observed facts. Some years before he wrote the *Principia,* he calculated the gravitational effect on the relative movements of the moon and the earth, but found the result inconclusive, because of an incorrect value of the length of a degree of latitude on the earth's surface. Later, when he received a more accurate measurement made by Picard, a re-calculation showed that Newton's hypothesis was correct.

There is an interesting record of Newton's ability to solve complex problems with his method of fluxions. Bernoulli issued a challenge to the mathematicians of Europe to solve two problems that he proposed. After six months the time was extended. Later, the problems came to Newton's attention and he solved both the following day. Newton lectured on optics and demonstrated the prismatic spectrum. He also was a chemist, and as warden of the mint he made a table of the assay of foreign coins.

Following the momentous proof of a universal law of the universe, there was a revival of interest in seeking solutions of the "irregularities" of orbital motions. Among the many striking instances was the return of Halley's comet to perihelion on March 12, 1759. Alexis Claude Clairault (1713-1765) had calculated the amount of the retardation of the comet due to the gravitational effects of Jupiter and Saturn, and the approximate agreement with the actual event was a splendid visible proof of this universal law.

AURORA IN A COMET'S TAIL?

Julie M. Vinter-Hansen, writing in the *Publications* of the Astronomical Society of the Pacific, reports on some interesting comet observations published originally in the International Astronomical Union *Circulars,* received recently from Europe. Arend, at Uccle, Belgium, noticed a nebulous object of 13th magnitude with a nucleus, close to Comet Whipple (1942g) on March 29, 1943. Measurements indicated that the position of the object must have coincided with that of the comet on March 28.5. Dr. Brunner-Hagger, at Zurich, Switzerland, had photographs of the comet on nearby dates which seemed to confirm the hypothesis that the object had split off from the comet on March 28.5.

But Brunner-Hagger noted that a fine aurora had been seen on March 27.8. Terrestrial aurorae are caused by corpuscular radiation from the sun. Suppose the diffuse object in the comet's tail had the same origin? From the time elapsed between the aurora and the formation of the cometary object, he deduced that the solar corpuscles travel at the rate of about one astronomical unit in 30 hours. Other Comet Whipple photographs showing similar spots were available for the period February 28th to March 4th. Solar eruptions had occurred February 26th-28th. Again correlating the two phenomena, Dr. Brunner-Hagger found similar velocities for the corpuscles.

LARGEST OBJECTIVE PRISM

Last August we reported on the successful casting of the largest objective prism in existence. The grinding and polishing of the prism for the Warner and Swasey Observatory of the Case School of Applied Science has been completed by Robert Lundin, of the Warner and Swasey Company — the same firm that constructed and erected the 36-24-inch Schmidt with which the prism is being used.

The original piece of optical glass weighed 260 pounds and was 26.75 inches in diameter. The finished prism weighs 100 pounds, and has a diameter of 24.5 inches. The prism was mounted in the telescope on December 12, 1943, and extensive tests were made during the following two months. The spectra obtained have a dispersion of about 0.13 inches between the hydrogen Balmer lines H-beta and H-epsilon (wave lengths 4861 to 3970 angstroms). So excellent is the definition in these short spectra that at least 21 lines could be identified in the $F5$ spectrum of Alpha Persei.

THE SUN A

By Ma

We study the sun with ever-increasing r
here and in the Hayden Planetarium. His
eclipses is an essential a

Partial eclipses may be seen over wide areas of the earth. This shows the eclipse of April 7, 1940, photographed by the Rev. William Kearons at Fall River, Mass. This eclipse was annular in the Gulf states.

THE SUN is a vast source of energy for all those who live upon the earth. Ordinary star that it is, it supplies, in direct or indirect fashion, the fuel that we burn, the food that we consume to keep our bodies active, the energy that we receive directly in sunlight and heat, and makes possible the great output of hydroelectric power plants. Without the sun, life upon the earth would shortly become an impossibility, and our planet a dead world.

The ancients believed that the sun was on fire and that its heat and light came directly from its burning. Today we know that the sun is not on fire in that sense, but is rather an enormous ball of incandescent gas, glowing and hot. One of our first questions, naturally, is as to the source of the energy produced by the sun, if it is not actually in a state of combustion. For each square mile of earth's surface, the sun radiates 643,000 horsepower of energy. For the entire earth this would amount to about 127,000,000,000,000 horsepower, or approximately 63,000 horsepower for every inhabitant. This means that this great solar mass of incandescent gas radiates about 77,000 horsepower per square yard of its surface.

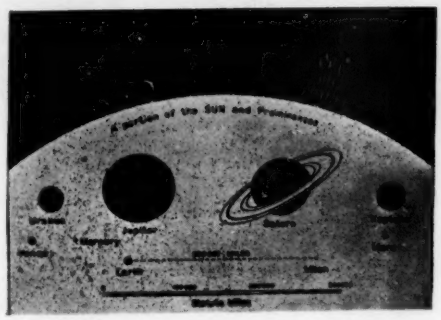
We realize that the energy of the sun cannot possibly be produced by combustion, because if this were the case the sun would have been used up long ago. Probably the source of the sun's energy is in the annihilation of the matter which composes it, for the sun is actually using up the material of which it is made at the rate of about four million tons a second. Even at this rapid rate of liquidation, it is estimated that our star will endure for about 16 million million years more.

In the interior of the sun almost inconceivable pressures and temperatures exist. Because of this great heat and pressure the atoms of sun-stuff (gas) of which the sun is made are continually being broken up. In this process the electrons are stripped from their central atomic nuclei. This subatomic activity is probably responsible for the sun's outpouring of energy.

Obviously it has been possible to learn more easily about the nature of the sun than of the other stars, since it is a mere 93 million miles from the earth, while the next nearest star is about 26 trillion miles away. We know that the diameter of the sun is about 864,000 miles, making this vast star about 1,300,000 times the size of the earth. If we were to place the earth at the very center of the sun, allowing the moon to continue to move around the earth as a satellite, and at its present distance of about 240,000 miles from our planet, the moon's orbit would still be only about half way from the center of the sun to its surface, and both earth and moon would be within the ball of the sun.

The temperature at the surface of the sun is about 10,000 degrees Fahrenheit, and at the center probably about 35,000,000° F. The force of gravity at the surface of the sun is about 28 times that at the surface of the earth, so a man weighing 150 pounds here on the earth would weigh somewhat over two tons if he were able to survive the sun's heat long enough to get himself weighed.

When Galileo first turned his new telescope toward the sun he discovered on its surface peculiar dark markings which he first interpreted as "solar clouds." These sunspots, as they have come to be called, are in reality vortices or great cyclones in the hot gaseous body of the sun, or areas of storm in the photosphere or light-sphere, that part of the sun which is visible to us. Sunspots undoubtedly range in size from those which are too small to be seen to those groups which have diameters of as much as 100,000 miles. A typical sunspot is dark in the center (the umbra) and may have a diameter of 20,000 miles or more. Around the umbra is a more lightly shaded section known as the penumbra.

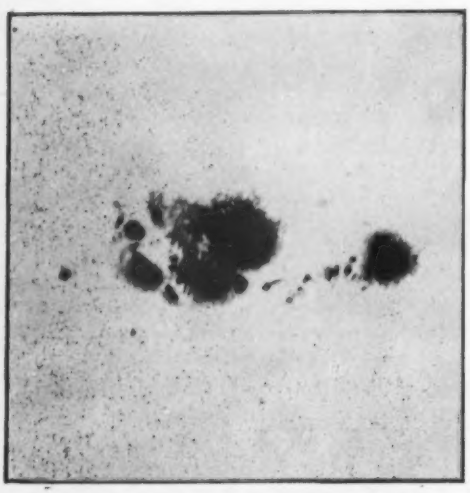


Comparative sizes in the solar system.

Another way of describing sunspots is to say that they are electromagnetic storms on the sun. From them great masses of electrified particles stream out, some of them impinging on the atmosphere of the earth, and causing terrestrial electromagnetic storms, radio upsets, and even the beautiful aurora borealis or northern lights, all the result of the electromagnetic disturbances on the sun some 93 million miles away.

Sunspots appear in cycles of about 11 1/3 years from one maximum to another, and are usually found only in the "royal zone" of the sun, from about 30 degrees north of the sun's equator to about 30 degrees south. Never are they found beyond 45° of solar latitude, north or south. The spots vary in their persistence, some lasting only a few days and others remaining visible over a period of months.

The sun plays its part in many of the

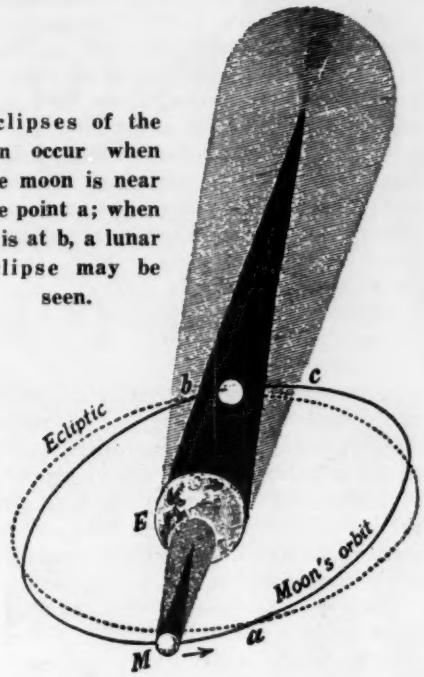


Sunspot groups are usually dominated by a leader and a follower spot.

AND ECLIPSES

By Marian Lockwood

reasing realization of its importance in our lives, as told
rium this month. How the sun and moon together produce
sential and interesting part of the story.



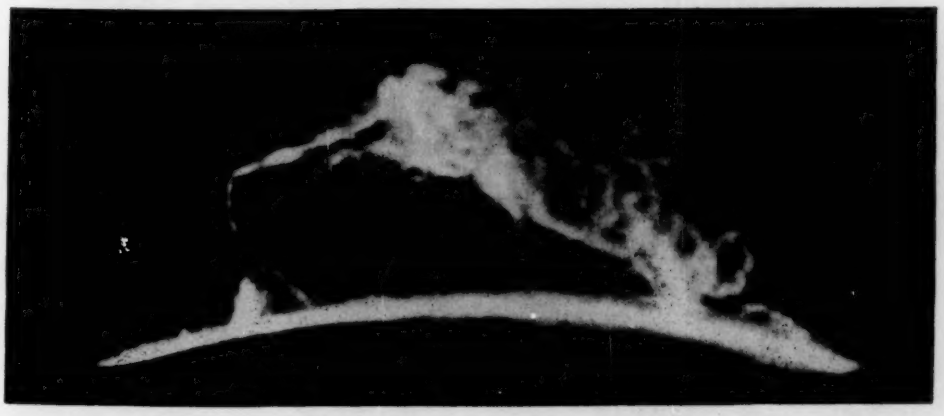
Eclipses of the sun occur when the moon is near the point a; when it is at b, a lunar eclipse may be seen.

most beautiful sky effects. But there is nothing — rainbow, sunset, or glorious sunrise — that can exceed the beauty of a solar eclipse. By a happy coincidence, to an observer on the earth the sun and the moon appear to be of about the same size. Actually, the sun is about 400 times as large as the moon, but it is also just about 400 times as far away, which makes our two luminaries appear of equal size.

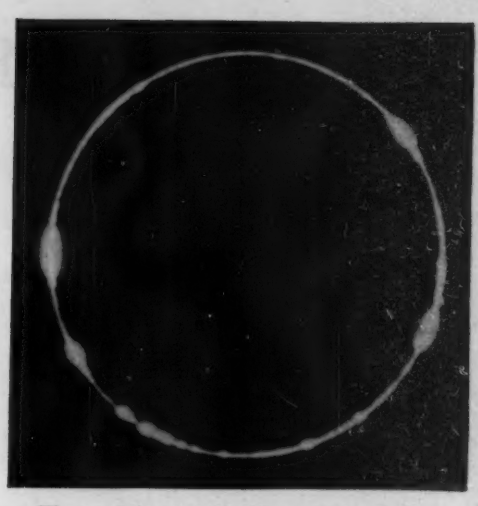
During the lunar month the moon, which is a solid opaque body, travels around the earth from west to east, during this time passing through its entire cycle of phases. The moon has no light of its own, but shines by reflected sunlight only. When, therefore, it passes between the earth and the sun, the dark side of the moon (the side turned away from the sun) is turned toward the earth, and no moon can be seen. When, as sometimes happens, the three bodies, earth, sun, and moon, are in a straight line, the opaque disk of the moon cuts off the light of the sun and a solar eclipse results. This does not happen each month at new moon, or dark of the moon, for the moon's path around the earth is tilted about five degrees to the plane of the ecliptic. This brings the moon usually either a little above or a little below the line between earth and sun.

The moon's distance from the earth varies considerably, from about 222,000 to about 253,000 miles. Because of this variation, sometimes our satellite appears to be larger than it does at other times. If an eclipse of the sun occurs when the moon appears large enough to cover the surface of the sun completely, and the moon is centered against the sun's disk, the eclipse is total. Partial eclipses occur when the moon, whatever its apparent size, is not centered against the sun. The total eclipse is by far the most beautiful, since it is only in this type that we can see the surpassingly beautiful corona.

The corona is the outer envelope of the sun's atmosphere, exceedingly thin and tenuous, and still very much of a mystery to astronomers. During a total solar eclipse, at the moment when the black disk of the moon completely covers the sun's bright one, the corona flashes out like a pearly-gray halo of luminous beauty, and can be seen during the entire period of totality. Just before and after the period of totality, Baily's beads appear for a brief instant. These are



Solar prominences extend tens of thousands of miles above the sun's surface.



The annular-total eclipse of April 28, 1930, furnished Lick Observatory astronomers an unusual opportunity to photograph Baily's beads completely around the sun. Totality lasted only one second.

bright spots of light which look almost like the diamonds in a ring, and are caused by the last rays of the rapidly eclipsing sun shining through the uneven valleys of the moon, along its periphery.

A particularly interesting kind of partial eclipse is the annular or ring eclipse. This can occur only when the moon is so far from the earth that it does not seem to be as large as the sun, and therefore cannot cover it up completely. In this type of eclipse the black disk of the moon is centered against the bright one of the sun, leaving a ring of light around the outside, and from this annulus or ring comes the name *annular*.

The last total eclipse of the sun visible from Manhattan Island occurred on January 24, 1925. The last one preceding that and visible from Manhattan was in the 15th century, while the next one visible from New York City will come on October 26, 2144. In the meantime, however, there will of course be many total eclipses of both sun and moon visible from other parts of the world. Undoubtedly, when the war is over, astronomers will resume their habitual traveling from one part of the world to another in order that they may miss none of the observing opportunities which come with a total eclipse.

And so the sun, that distant yellow ball of gas which lights our days for us, is the source not only of almost all our energy, but of a great amount of the beauty which surrounds us in this terrestrial life. Not only the rare beauty of a solar eclipse, but also the blue of the sky, the sunset colors of orange, green, and red, the color of the oceans and deeply secluded mountain lakes, the refreshing quality of spring rain, the snow which delights all country hearts, the rainbow, the majestic beauty of the thunderstorm — all these and many more exist because of the activity of the sun.

NEWS NOTES

By Dorrit Hoffleit

PURE ASTRONOMY FOR ARMED FORCES

In this country we hear a great deal on the one hand about the time astronomers devote to teaching the armed forces navigation; and, on the other hand, about dances, movies, and various other cheer dispensers for the men. Comparatively little is done about purely cultural entertainments. The Royal Astronomical Society and the British Astronomical Association set a fine example this winter by sponsoring a series of popular astronomical lectures open only to members of the forces. The topics included Photographic Astronomy (Sir James Jeans), The Origin of the Earth (W. M. Smart), The Planets and Planetary Observations (B. M. Peek), The Movements of the Stars (H. Dingle), Life on Other Worlds (Will T. Hay), and The Determination of Stellar Distances (F. J. Hargreaves).

In peace times, such lectures in this country are usually well attended. Would not our men in military areas respond as enthusiastically as they did in civilian life, enjoying an hour away from earth?

PUBLICATIONS, TEACHING, AND RESEARCH

Vol. 10, No. 8, concludes the *Publications* of the American Astronomical Society as a separate publication. This number, which has recently been distributed, contains abstracts of the 19 research papers presented at the meeting of the society held in Cambridge on May 28-30, 1943, and the annual reports from 13 observatories for the year ending June 30, 1943. Future material of this nature will appear in the *Astronomical Journal*, whose publication has been taken over by the American Astronomical Society.

Reports of observatories, as usual since 1941, note the depletion of staffs due to the war effort, with the consequent reduction of research. The sizes of astronomy classes during the war are of interest. Fuertes Observatory (Cornell) reports 300 astronomy students, of whom about 50 per cent were in navigation courses. The University of Michigan had 670, with 130 in navigation. Washburn Observatory (Wisconsin) reported about half the usual number in astronomy, which was more than compensated by the registration in the classes in navigation (about 50 each semester).

The writing by astronomers of several texts on navigation is noted. (In the first four issues of *Sky and Telescope* for 1944, incidentally, 10 recent or projected books on navigation and avigation have been advertised.) The war has thus given tremendous impetus to the study of stars as nearly infallible guides in certain mundane matters. At the same time, this has naturally been at the expense of studies of stars for the sake of knowledge concerning the nature of the stars themselves.

Research in astrophysics and other purely astronomical fields goes on, however, both at small and large observatories. The report from Yerkes and McDonald Observatories, in particular, although implying personnel loss quite in proportion to the sizes of the staffs, gives gladdening evidence of progress on many topics; even in peace time this report by one director would have looked encouraging!

NEW UNSEEN COMPANIONS

As if to commemorate the 100th anniversary of Bessel's prediction that Sirius has a companion, Dr. Peter van de Kamp, director of Sproul Observatory, has reported to the American Philosophical Society on his new discovery of unseen companions of two nearby stars which have heretofore been considered single. Barnard's star, of greatest known motion across the face of the sky, is one of the stars, and the other is Lalande 21185; they are, respectively, the second and (probably) third nearest stars to the sun.

In 1844, Bessel found the proper motions of Sirius and Procyon to be variable. With remarkable foresight, he predicted the existence of an invisible companion star for each of the visible ones; in 1862, Sirius' companion was found, and in 1896 Procyon was observed to have a faint companion star. Since then, many such "invisible" companions have been found, most of them, however, by spectroscopic means rather than by the proper-motion method used by Dr. van de Kamp.

In the case of a single star, the apparent motion is essentially in a straight line across the sky. But if the star has a companion, the two components of the system exert gravitational attractions on each other, and they tend to revolve in elliptical orbits around each other. Their center of gravity is the point that moves in a straight line in space. Thus, if the stars differ considerably in brightness, so that only one of them is observed, wavy deviations from straight-line motions of the visible star may reveal the presence of the unseen member.

As the proper motions of nearby stars are most noticeable, it is these that Sproul astronomers study with the utmost precision possible, but the detection of variations from straight-line proper motion is not an easy matter. Nevertheless, measurements of Barnard's star on over 700 plates, taken on 172 nights from 1938 to 1944, leave no doubt that the deviations from uniform linear motion are systematic and larger than the expected possible range of observational uncertainties. The deviations are cyclic, indicating that the unseen star moves around the visible star once every 1.07 years. Other facts revealed are that the semimajor axis of the companion's elliptical path is 0.118 astronomical units; its eccentricity, 0.20; its inclination, 70 degrees. The companion's mass cannot yet be evaluated since its luminosity is unknown. A lower limit, however, is set at 0.06 times the sun's mass. Hence, there is no question about its being a star; it is not of planetary mass. The primary Barnard's star is small and faint, a red dwarf 1/2,000 of the sun's luminosity.

Lalande 21185 (magnitude 7.6, visual), the third nearest star (Wolf 359 may be as close), is also a red dwarf star. For it, Dr. van de Kamp has found evidence for a companion revolving at a distance from the primary of 0.132 astronomical units in a period of 1.28 years; eccentricity, 0.72, as high as that of a typical comet orbit. This star cannot have less than 0.04 times the sun's mass, so it, too, is a genuine star.

Both of these new companions are so close to their primaries, on the order of 0".2 to 0".4, that actual visual observation at present is not expected. At such close apparent distances, the images of the two components are blended. It is as yet impossible to tell whether the stars are faint red dwarfs or the more interesting variety of white dwarf stars. Spectroscopic observations, however, may provide data to solve this question, for the orbits of both stars lie close to the line of sight. Ranges in radial velocity of about seven kilometers per second are expected, and these should give readily measurable displacements of spectral lines. It is anticipated that observatories properly equipped with large instruments will study the spectra of these important stars.

These new discoveries of companion stars indicate the rarity in space of single stars like our sun. As a student, I was once amused by a teacher's statement: "Probably three stars in every one are multiple!" This prediction is approaching verification. Of our five nearest neighboring "families," the closest is at least a triple star; the second is at least double; the next is at least double; Wolf 359 has not yet been adequately examined because of its faintness, magnitude 13.5; and the fifth, Sirius, is also at least double. Only the sun, among the six nearest stars to the earth, is surely single. According to some theories of the origin of the solar system, the sun was also at one time double, having become widowed with a family of satellite planets. The Sproul

results on Barnard's star and Lalande 21185 may be taken as lending some support to these theories.

Several other nearby stars are being intensively investigated at Sproul Observatory, but the law of diminishing returns (see *Sky and Telescope*, February, 1944) is already operating. The more distant the stars, the more difficult it becomes to separate small orbital displacements from natural observational uncertainties; the sizes of the latter cannot be reduced below certain limits set by the equipment, the earth's atmospheric idiosyncrasies, and other causes. Meanwhile, the angular displacements due to orbital motions decrease steadily with increasing distance of the stars from the observer.

"NATURE," ASTRONOMICALLY INCLINED

The February 12th number of the British weekly, *Nature*, has a large proportion of notes on astronomy. The first article is on the Royal Observatory at Greenwich, an account of its history and why it should move to a new location. There are two reviews of books on air navigation, while Roy K. Marshall's article on "The Planetarium" in our November issue is abstracted.

The most important article is by Sir H. Spencer Jones, "Measuring the Distance of the Sun from the Earth." After surveying the various earlier methods: transits of Venus, observations of Mars, Jupiter's satellites and the velocity of light, the author tells of drafting the smallest planets, in particular tiny Eros, to help measure the astronomical unit—shortest and most fundamental unit of distance in astronomy, yet hardest to find with the required accuracy. Although the observations of Eros were made in 1931, the final answer was not extracted until 1941.

BRITISH ASTRONOMICAL ASSOCIATION

At the latest annual meeting of the B.A.A., its president, F. J. Hargreaves, reported that a goal had been overshot. His predecessor, F. J. Sellers, had set as "a target: one thousand members as a minimum." Not only had this mark been reached, but the rate of increase had not yet decreased. On October 1, 1942, the membership in the society was 856; a year later it was 1014.

Answers to

AN ASTRONOMICAL FABLE

(Story on page 6)

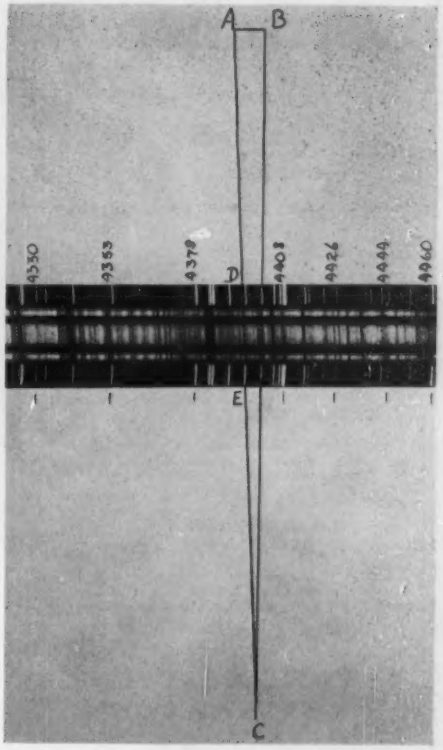
Kids, cluster, great dog, little dog, Puppis, variable, Aries, Mira, minor, Sirius, Cancer, planet, eclipse, Messier, Antares, Cepheid, Castor, Saturn, Betelgeuze, Taurus, satellite, comet, Phaed.

The Rotation Period of Saturn

By Helen B. Pettit

Pasadena Junior College Observatory

WHILE devising a series of laboratory experiments on spectroscopy for a class in astronomy at Pasadena Junior College, I saw the article on "Our Planetary Neighbors" in *Sky and Telescope* for March, 1944, containing a spectrogram of Saturn and its rings. It occurred to me that since this spectrum is on such a large scale, it would be possible to make a determination of the rotation period of the planet without the aid of a measuring machine. For the purpose of class work, reproductions on nearly the original scale were made on 4 x 5 paper prints and given to each member of the class for measurement. One of these is shown in the figure.



The steps necessary to determine the period of rotation of Saturn[1] are given in outline form as follows:

1. The scale of the spectrum (dispersion) can be obtained either from the solar lines in the spectrum of Saturn or from the comparison arc (vanadium). The comparison arc is more convenient since the lines can be identified from A. S. King's paper[2]. These wave lengths are noted on the photograph. If lines near the middle of Saturn's spectrum are chosen for determination of the rotation period, lines at wave lengths 4330 and 4460 at the extremities of the comparison spectrum can be used to determine the scale of the spectrum, and the small variation of dispersion over the spectrum will be avoided.

2. To determine the difference in wave length between the two limbs of Saturn due to rotation, the scale has to be enlarged in order to increase accuracy. It was found that an enlargement of 30 times was adequate.

a. Measure the width of the planet's spectrum in millimeters.

b. Lay a glass plate or other straight edge along a pair of the comparison lines and extend these lines (*BC*).

c. Draw another such line through a neighboring solar line in Saturn's spectrum (line *AC*), and from the intersection *C* lay off *CB* equal to 30 times the width of Saturn's spectrum.

d. The displacement *AB* is then measured in millimeters.

e. Now to return to our normal scale, divide the above value by 30.

3. The displacement in mm. (from 2e, above) is now changed to angstrom units by use of the dispersion from (1).

4. This value is the Doppler displacement of the spectrum at the two limbs of Saturn. Therefore, we must divide by two in order to obtain the Doppler displacement due to rotation.

5. Now we determine the radial velocity using: $V = c\Delta\lambda/\lambda$, where $\Delta\lambda$ is the value just determined, c = 186,000 mi./sec., and λ is determined by noting the λ of the comparison spectrum nearest the line measured.

6. The period of rotation equals the circumference divided by the velocity, which for Saturn is 73,000 pi/vel. sec., or 229,000/velocity x 3,600 hours.

Using four lines which produced an average value of $AB = 6.6$ mm.[3] and with a scale value of 1 mm. = 1.347 angstroms, I obtained a rotation period of $10^h\ 7^m.2$. J. H. Moore[4] has obtained $10^h\ 02^m$ for the equatorial rotation period by observing the angle of inclination of the lines to be $2°.66 \pm 0°.02$, using a measuring machine provided with a circle. The accepted value obtained by the observation of a spot on the planet itself is $10^h\ 14^m$.

Of course, in our problem we do not know that the spectrograph slit was set exactly along Saturn's equator, and there may be some error in estimating the diameter of the planet from the spectrum, but the result seems to justify the application of this crude method to instruction purposes.

[1] Standard textbooks may be consulted for an explanation of how the rotation of a planet produces a Doppler shift in its spectral lines; also, how this spectrogram gives proof of the planetesimal character of Saturn's rings. ED.

[2] Mount Wilson *Contributions* No. 94, *Ap. J.*, *41*, 86, 1915.

[3] Space has required reduction of the size of the author's original illustration in the ratio 25 to 14. ED.

[4] *Pub. A. S. P.*, *51*, 274, 1939.

The Harvard Books on Astronomy

Edited by Harlow Shapley and Bart J. Bok

Harvard College Observatory

- **GALAXIES**
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  In this interesting study of galaxies the reader is taken hundreds of millions of light-years to the spaces now reached by the greatest photographic telescopes. 126 Illus. $2.50

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  The dust and gases in the vast spaces between stars, star clusters and problems related to the future of our galaxy are discussed. Large scale photographic maps are included. 93 Illus. $2.50

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  By LEON CAMPBELL and LUIGI JACCHIA
  The reader is introduced to the technique of observation and shown how to analyze our knowledge of variable stars. A list of brighter variables, a Julian calendar and other tables are included. 82 Illus. $2.50

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BOOKS AND THE SKY

MR. TOMPKINS EXPLORES THE ATOM

G. Gamow. The Macmillan Company, New York, 1944. 97 pages. $2.00.

SINCE the issuance of Prof. Gamow's earlier book, **Mr. Tompkins in Wonderland,** its many admirers have been hoping for a sequel. For Prof. Gamow succeeds remarkably well in those most difficult tasks, the popularization of the almost wholly mathematical developments of modern physics, and the writing of a fantasy on highly technical subjects that has the readability of the products of the earlier mathematician who created the original Wonderland.

In **Mr. Tompkins Explores the Atom,** as in its forerunner, Prof. Gamow achieves his ends by resorting to two distinct levels of popularization. In the first part of both books are series of dreams illustrating some aspect of modern physical speculation, and in the latter part, a series of lectures containing an only slightly less popularized version of the same material. The present volume contains three "dreams," entitled "Maxwell's Demon," "The Gay Tribe of Electrons," and "The Woodcarver." The title of the first dream is self-explanatory; in it Mrs. Tompkins sees Maxwell's demon at work reversing the second law of thermodynamics. In the second dream Mr. Tompkins becomes a planetary electron, participating in atomic and interatomic dances until annihilated by a wandering positron; and in the third he visits a shop where atomic nuclei are made and transformed, and becomes acquainted with protons, neutrons, electrons, positrons, and a closed box which might or might not contain neutrinos.

The four lectures cover atoms and

From the jacket design for "Mr. Tompkins Explores the Atom" By George Gamow

THE THEORY OF THE GYROSCOPIC COMPASS AND ITS DEVIATIONS

By A. L. RAWLINGS

A revised edition of the only complete book on the theory of the gyro-compass which is used in virtually all ships of the navies and merchant marines of the Allied Nations. The book is especially valuable for advanced instructors in gyro-compass and navigation schools. Seventy photographs and drawings. $3.00.

SPHEROGRAPHICAL NAVIGATION

By DIRK BROUWER, FREDERIC W. KEATOR *and* DRURY A. McMILLEN

Foreword by CAPTAIN P. V. H. WEEMS, *Annapolis*

This book is a manual of instruction on a system of celestial navigation called Spherographical Navigation. While the system is based upon principles which are of considerable antiquity, it is new in the sense of its instrumentation and in its practical application to the solving of the problem of position. *Illustrated* — $5.00.

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molecules, wave mechanics and the structure of the atom, Dirac's ocean, and nuclear structure.

The second volume is an improvement upon the first in one important way; it has less of the dogmatic assumption of the correctness of currently held theories: a dogmatism which is unwelcome even though it be part of the simplification which is the necessary price of popularization. As is almost invariably the case where a successful book calls forth a sequel, the sequel fails to rise to the inspirational heights of the original, and the dreams impress one as being relatively pedestrian. Even so, the volume is a most welcome addition to this form of literature.

LAURENCE J. LAFLEUR
Antioch College

TOMORROW WE FLY

William B. Stout and **Franklyn M. Reck.** Thomas Y. Crowell Company, New York, 1943. 160 pages. $2.00.

DO YOU remember Marie Dressler's dizzy act when she tried the Link trainer? That was my feeling as I read **Tomorrow We Fly,** some parts of which made me dizzier than reading 12,000 feet on the altimeter of my 65-h.p. Cub coupé over Mt. Baker. Cows, pigs, pianos, perishable foods, and nursing babies sail through the air at incredible speeds in future ornithopters driven by uranium 235.

If you wish a zest for living, read this book. I hope to live to see the realization of many of these new inventions of William B. Stout's creative imagination. Think of John Public and his family jumping into their private helicopter and hopping off to Whitehorse, Alaska; Rio, South America; or Chungking, China!

As a basis for realizing future hopes, the authors have recorded the marvelous achievements in aviation. The trimotor envisioned by Stout and built by Henry Ford constituted the first all-metal plane and was the first to carry mail. Large transports for commercial aviation were developed. Airways have been established with beacon lights, radio beams, and tower control to guide the pilots to paved and lighted runways. Before the war, Pan American Amphibians and China Clippers annually landed hundreds of thousands of passengers in distant ports.

The realist can ask, "Can the cost of overhead and transportation be lowered to make large-scale commercial aviation feasible? Will the cost of the family flivver be within the average budget? How can the uncertainty of bad weather be satisfactorily met?" All these questions and others are answered. Of course, nature's laws cannot be changed, but future airways will be above weather, above the turbulent troposphere. Mr. Stout claims the helicopter will be the solution of the light plane problem.

Undoubtedly, for future development more power will be required. Multiple engines and multiple rotors may be used. The authors discuss the use of rocket propulsion, which removes the speed limit once fixed theoretically at 750 miles per hour, the speed of sound. The possibility of harnessing atomic energy is proposed. "One pound of Uranium-235," according to the authors, "equals 400 tons of coal." Although these speculations seem visionary, science and invention are always doing the impossible.

LT. MAUDE SQUIRE RUFUS
Civil Air Patrol

SPHEROGRAPHICAL NAVIGATION

Dirk Brouwer, Frederic W. Keator, and **Drury A. McMillen.** The Macmillan Company, New York, 1944. 200 pages. $5.00.

THE APPEARANCE of this book may be looked upon as something of an event in view of the interest created in this system of navigation and the resultant controversy. Certainly there is really nothing new about using a sphere for the purpose of plotting circles of position for celestial bodies. What is new is that at last someone has actually constructed an accurate sphere upon which the many kinds of problems can be solved, and has

(*Continued on page 21*)

NEW BOOKS RECEIVED

CLOUDS AND WEATHER PHENOMENA, *C. J. P. Cave,* second edition, 1943, *Cambridge University Press; Macmillan.* 22 pages plus illustrations. $1.75.

An entirely new edition of this book, which first appeared in 1926, includes short notes on many of the most interesting phenomena of the sky, its color, rainbows, haloes, mirages, and some rarer sights, as well as 42 photographs of cloud formations, which should serve the beginner admirably as guides to cloud identification.

MARINE AND AIR NAVIGATION, *Stewart* and *Pierce,* 1944, *Ginn.* 472 pages. $4.50.

A complete, self-contained textbook of navigation, with the discussion throughout unifying principles in marine and air navigation, and simultaneous treatment of problems in both types of navigating. Numerous charts and tables, and 275 drill problems with answers, are included.

ROCKETS, The Future of Travel Beyond the Stratosphere, *Willy Ley,* 1944, *Viking.* 287 pages. $3.50.

The history of rockets, and a popular but scientific account of future rocket development and possibilities.

Sky Publications

Relativity . . . . . 50¢

The astronomical implications of the general theory uniquely described in the language of the intelligent layman. By Philipp Frank, of Harvard University.

400-Year Calendar . . . . 10¢

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GLEANINGS FOR A. T. M.s

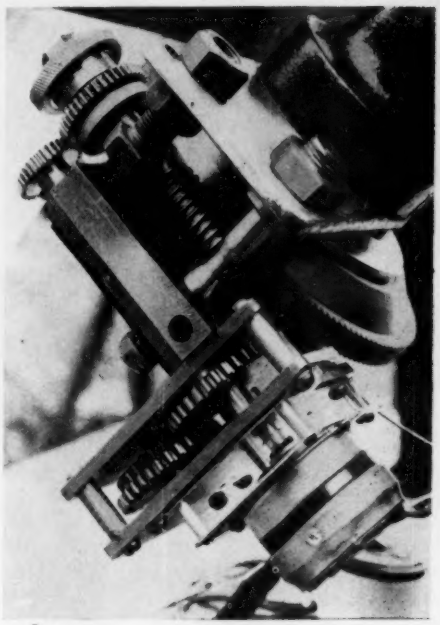
An Efficient But Low-cost Telescope Drive

WHEN in July, 1941, we decided to add a 10-inch reflecting telescope to the equipment of the ivy-walled Evergreen Observatory at our home, we soon realized that haste was essential or we should be unable to get anything at all. Most of the telescope manufacturers reported they could do nothing — excepting for the government. We did find two who would work on private orders, but for only two or three months longer.

We hoped to keep the cost relatively low, yet to obtain an efficient product. From one manufacturer we hurriedly ordered the tube, complete with finished optical parts and other accessories; from the other, the rough castings for the mounting, together with the blueprints for their proper machining. All these were delivered without undue delay, and the needed machining was done locally at low cost.

Then came the problem of an electric drive. We expected it would cost somewhere around $100, but where could it be bought? In the May, 1940, number of **Popular Astronomy,** D. F. Brocchi had published interesting information on gears and small motors available for drives for telescopes of moderate size. Inspired by this article to make our own, we proceeded to figure out gear ratios and to find where we could buy gears and a motor. From the motors available, we selected the little Hansen Synchron — so small it can be enclosed in a man's hand — with a shaft speed of 1 r.p.m. and a torque of 0.5 pound-inch. Spur gears were still on sale by some of the large companies and were bought in time. But when we were ready to purchase the worm gear (ratio 1 to 180) for the friction disk at the end of the polar axis, proper priorities could not be secured, so we had to be content with a large spur gear (ratio 1 to 144) obtained from a friend's dismantled cream separator. By cutting away a little from the corners of the 144 teeth, this works quite smoothly with the worm. This change in plans after the other gears were assembled necessitated the addition of two more gears of 32 and 40 teeth, respectively.

The money outlay for the completed product as shown in the photograph was $9.22. The motor and the gears were



paid for at regular prices. Now comes the secret of the low cost. The metal-working department of the Eugene Vocational School was anxious to get the assembling of the parts as regular work for its students, so no charge was made for this aside from the materials actually used. The finished drive is as efficient as if made in a high-priced machine shop. The students at this school, under the supervision of their instructors, also did most of the machining on the rough castings for the telescope mounting.

Perhaps the calculation of the gears may be helpful to anyone who after the war may care to fix up a good drive. The sidereal day has a length of $23^h\ 56^m\ 4^s.1$. If carried to no more decimal places in the seconds, this is also the time of one rotation of the earth. The problem then is to calculate the number of teeth needed on the various gears to change the one revolution per minute of the shaft of the motor to one revolution of the last gear (on the polar axis) in one sidereal day, or 1,436.068 mean solar minutes. It is seen that there would be only 0.068 minutes (four seconds) of error per day if the worm were fastened directly to the

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shaft of the motor and engaged a gear of 1,436 teeth on the polar axis. The motor shaft turning 1 r.p.m. would turn the polar axis 1 r.p.(1,436m.). This would be splendid for general visual observations. But such a gear would be too big for the purpose, could not be found in stock, and would have to be manufactured on a special — and very expensive — order. It is far better to make the reduction through several small gears.

Numerous gear combinations are possible, giving various degrees of accuracy. That finally adopted was 13/36 27/33 14/33 32/40 1/144. The meaning is this: the gear of 13 teeth is fastened onto the shaft of the motor and engages the gear of 36 teeth which is fastened to another shaft. Onto the same shaft with the 36 is attached the 27, which in turn enmeshes with the 33. Each denominator and the following numerator are therefore concentrically attached to the same shaft. The final 1/144 represents the worm engaging its gear.

In the picture, the little motor is seen at the lower right just in front of the electric switch which is resting on the top of the concrete pier. In the metal framework to the left of the motor there are six gears, although only three show. It is seen that the lower two are fastened close together on the same shaft. The one above these (33 teeth) is fastened through a long shaft to the smaller-sized gear (32 teeth) near the upper left side of the picture. The latter enmeshes with the 40-tooth gear which is fastened to the worm.

If we multiply the gear-train fractions indicated above, and reduce to lowest terms, we obtain 91/130,680, or 1/1,436.-044. Since there are 1,436.068 minutes in a sidereal day, the error is only 0.024 minutes, or 1.4 seconds per day.

This drive is highly satisfactory, and with the smooth-running telescope mounting keeps a star in the center of the field without noticeable error during a long observation. The little Synchron motor could handle a telescope much larger than a 10-inch.

J. HUGH PRUETT

University of Oregon, Eugene, Ore.

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Classified advertisements are accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

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ASTRONOMICAL ANECDOTES

EDITED BY EARLE B. BROWN

"PLANETS," "ARNOLD," AND SOVIET TELESCOPES

I'M AGIN it when public enthusiasm pronounces a faint object a planet because its mass and luminosity are lower than that of previously known stars. I'm very glad Bessel wasn't so precipitate when he predicted the presence of companions to Sirius and Procyon. Jupiter, if revolving around one of the components of 61 Cygni, would be approximately of magnitude 26. If we can reach magnitude 23 or 24, sometime soon, and we still don't find a trace of the companion of that star, then we may consider the possibility that we have found a planet in another system. But surely we have no right to bridge a gap of four or five magnitudes without a little thought in the matter.

But what brings this up is the fact that Dirk Reuyl, at Leander McCormick Observatory, University of Virginia, has discovered a component of mass even smaller than that of the much-touted 61 Cygni *C;* it is associated with the well-known 70 Ophiuchi pair. In Mary Proctor's *Evenings with the Stars,* published about 20 years ago, I find this concerning 70 Ophiuchi:

"It has been suggested that there may be a third and invisible companion. . . . If the disturbing object is a planet like our own, basking alternately in the rays of light from the red and the golden sun, what a strange diversity of color effects must prevail on a world so illumined."

Four times I have heard as fine a bit of modern sophisticated whimsy as anyone has written, in a radio program; it is a production of the very skillful Norman Corwin, entitled *The Odyssey of Runyan Jones.* It has a very clever ending, which will bring a tear to many an eye; throughout most of the half hour, however, there are almost continuous chuckles, especially for those interested in astronomy.

Runyan Jones is looking for his dog Pootzy, who has been consigned to Curgatory because he was killed while chasing automobiles. He consults "F. T." (Father Time), who complains that he is thoroughly ashamed of the kind of time that is kept at Greenwich; "it's so *mean,* that's why!" He talks to Mother Nature, who catches her secretary, Blossom, with a thermos bottle filled with warm nectar. She smashes the bottle, exclaiming, "Don't you know I abhor a vacuum?" He talks with a harpy, and with a giant, and. . . . But you've got to hear it someday, for it is a wonderful thing.

I wanted to get in some reference to Greenwich, for the *Evening Standard* of December 11, 1943, has announced the death of Miss Elizabeth Ruth Belville, the owner of "Arnold." "Arnold" is a watch made for one of the sons of George III; the name comes from the maker, A. J. Arnold. Its accuracy has been known since 1836 to be remarkable. Thrice weekly, Miss Belville carried "Arnold" to Greenwich, as did her father and mother before her, to receive certification as to the accuracy of the old watch. She then would transport the time to business houses, watchmakers, and shops in the city. Her last round was made in September, 1940. She died at the age of 89.

When Thomas Carlyle complained that "a common clerk" had been given the job of astronomer at Edinburgh — a position to which Carlyle aspired — he was speaking of Henderson, who later went to the Cape of Good Hope and made the observations from which he derived and, in 1839, published his value of the parallax of Alpha Centauri. Almost everyone knows that Bessel, in 1838, had published a value of the parallax of 61 Cygni; it was 0″.314, whereas the modern value is 0″.294.

Dr. Otto Struve points out that his great-grandfather, F. G. W. Struve, in the Latin introduction to his *Mensurae Micrometricae,* published in 1837 a parallax of Vega; his value was 0″.125, whereas the modern value is 0″.123. This is very close, but Dr. Struve considers that the probable error, approximately four times as great as that of Bessel's first parallax, does not entitle him to press the claim too strongly. After all, it was the work of Bessel, with its low probable error (0″.014), that stimulated other workers and convinced astronomers at large that the distances of at least some of the stars might be measured.

The continuity of the observatory established by F. G. W. Struve at Poulkovo has at last been interrupted; there seems reasonable ground for hope, however, that at least the optical parts of the instruments, including the great 30-inch objective originally figured by Alvan Clark, were saved from destruction by bombs and shells during the siege of Leningrad. And the plans announced by the Academy of Sciences of the U.S.S.R. are magnificent in the extreme: after the war, there are three large reflectors projected, of apertures 120, 80, and 80 inches, one of them to be located perhaps in Africa, the others in the Crimea. Perhaps another 30-inch refractor is contemplated, too, according to the reports, as well as many other instruments, some of new design. Astronomers all over the world will be happy to see these things come to pass.

R. K. M.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

EQUATION OF TIME

JUNE 13th and 14th will be days on which the equation of time is nearly zero — sun time and local clock time will agree so closely that one's local meridian may be established easily. The shadow cast by the sun at 12:59:54 p.m. Eastern war time on the 13th, and at 1:00:07 p.m. on the 14th, will be exactly north and south on the 75th meridian. As the equation of time is then changing by about one second in two hours, these times may be used all over the United States, but it will still be necessary to apply the difference in longitude between one's position and the standard time meridian for standard war time.

Using the shadow cast by the sun in this manner reminds me of April 25th on the island of Barbados (lat. 13° 5′ N.) where I had a winter home for seven years. The sun on its northward journey would be overhead each year on April 25th, and at noon was only two minutes ahead of mean time. At one of our clubs there was a 10-inch square free-standing post that had been erected perfectly plumb. There was a regular ceremony on that date when the members would gather for 15 minutes before 12 o'clock to watch the shadow, cast by the post, gradually lessen until it disappeared entirely.

MARS IN PRAESEPE

MARS, on June 1st and 2nd, travels through that interesting group, the Praesepe cluster, which was described in detail in the April issue. The planet, magnitude 1.8, will be faint in comparison with its magnitude of —1.7 at last December's opposition, but it will stand out in sharp contrast to the stars in Praesepe, the brightest of which is magnitude 6.32. A low magnification of about 40x or 50x should enable an observer to encompass the entire 26-hour motion in the field.

At 8:00 p.m. on the 1st, Mars will be 13′ south of BD +20° 2136. Its southeasterly motion of about 1′.5 per hour will place it 14′ north of 107 B Cancri by 10:00 p.m. on June 2nd. These distances can be easily measured on my scale diagram in the April issue by comparison with the circle representing the moon, whose diameter is 30′.

Unfortunately, conjunctions with the brighter stars in the group, such as Epsilon, 39, 40, and 102 B, will occur in broad daylight.

CONJUNCTION BEFORE OCCULTATION

ON THE evening of June 29th, an interesting conjunction-occultation of the 6th-magnitude star 80 Virginis will be observed from New York City. At 10:10.8 p.m., the star will be in conjunction with the moon, at a distance to the south equal to four per cent of the moon's diameter. About eight minutes later, the occultation will begin, and will last 24 minutes, to about 10:43 p.m. Exact times are impossible to predict because of the mountains along the southern limb of the moon.

Usually a star is hidden by the eastern side of the moon first, and the conjunction in right ascension takes place while the star is occulted. In this particular case, however, the entire occultation takes place after the conjunction. This is caused by the rapid southward motion of the moon, which is not far from the autumnal equinox. The position angle of the moon's axis is 22°; immersion is at 191°, and emersion is at 225°; therefore immersion occurs about 11 degrees from the moon's south pole.

OCCULTATIONS FOR TEXAS

Predictions are for longitude 98° 0′.0 W., and latitude 30° 0′.0 N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, **a** and **b** quantities in minutes, and position angle in degrees, at immersion; G.C.T., **a** and **b** quantities, and P.A., at emersion.

June 5, Gamma Lib, 4.0; 2:50.8, —6.5, +8.7, 40°; 3:08.4, +3.5, —9.0, 15°.

June 5, Eta Lib, 5.6; 8:52.0, —1.1, +0.6, 51°; 9:36.8, —1.3, —3.3, 335°.

June 9, 50 Sgr, 5.6; 3:02.8, +0.1, +0.4, 109°; 4:00.2, —0.7, +1.2, 262°.

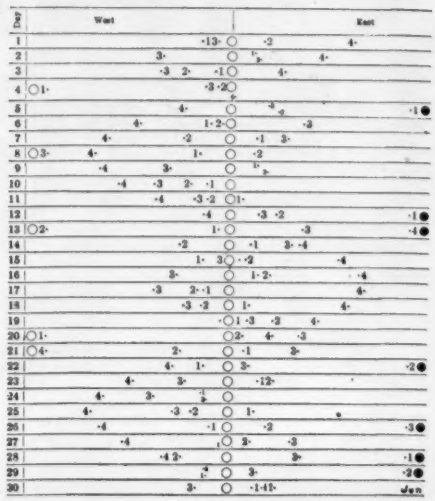
June 11, Gamma Cap, 3.8; 10:47.5, —1.7, +1.8, 36°; 12:00.7, —2.5, —0.7, 277°.

BY JESSE A. FITZPATRICK

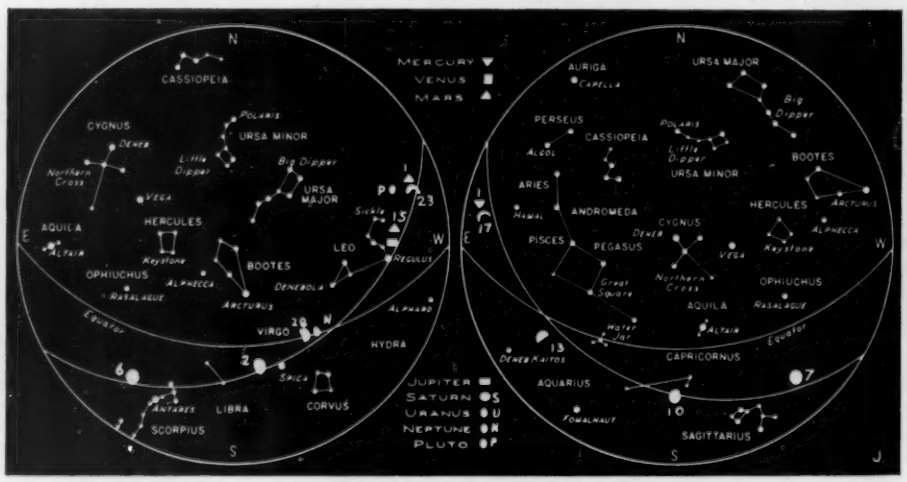
JUPITER'S SATELLITES

On June 9th and 23rd, the four moons will be west of the planet, and on the 19th before 9:20 p.m. they will be on the east side. On the 9th they will be in numerical order, with **I** nearest the primary.

Jupiter's four bright moons have the positions shown below at 11:15 p.m., E.W.T., on the day preceding the date shown. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.



THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 4:30 a.m. on the 7th of the month, and at 3:30 a.m. on the 23rd. At the left is the sky for 10:30 p.m. on the 7th and for 9:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, Venus, Saturn, and **Uranus** are too near the sun for observation.

Earth will arrive at heliocentric longitude 270° at 9:03 a.m., June 21st, with the sun in Gemini. Summer will start in the Northern Hemisphere and winter in the Southern.

Mars will be in Cancer and Gemini. The conjunction of Mars and the moon on June 24th, noted in the **Ephemeris,** will occur about noon in the vicinity of New York, and the planet's magnitude of 1.9 will make it invisible in an ordinary telescope.

Jupiter is in Leo, still a bright object in the evening sky.

Neptune, in Virgo, will resume its progressive motion on June 12th; see diagram in the February issue.

Pluto. See May issue.

OCCULTATIONS — JUNE, 1944

Local station, lat. 40° 48'.6 north, long. 4h 55m.8 west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
June 8	5.6	50 Sagittarii	11:32.6 p.m.	47°	0:24.2 a.m. (9)	319°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

AMATEUR OBSERVATIONS

SEVERAL letters have been received reporting on observations recently made by amateur astronomers. D. C. Wysor, of Ridgewood, N. J., writes:

"This is just to report that with my portable 6-inch f/10 reflector I watched Jupiter pass behind the moon on the stroke of 3:50 p.m., April 30, 1944.

"Visibility was not perfect by any means, but I could see the planet very well and judged that it required some 10 to 15 seconds for it to become eclipsed. This 'delay' in going out caused me to wonder, until I reflected that it was a very sizable disk instead of a star point that was being covered up."

From Leo Scanlon, in Pittsburgh, comes the following:

"We had a fine experience witnessing the occultation of Jupiter yesterday afternoon. We didn't have perfectly good weather for the event, as there was a thin cloud formation over the area in which it occurred, but the moon was easily seen at an early hour. It was not until 3:20 E.W.T. that we located Jupiter, first in a 6-inch reflector, then in a 2-inch refractor using 60x. From then on we followed it with both telescopes until the occultation was complete. We also saw the emersion of the planet. Immersion (to the nearest minute), 3:44 E.W.T., emersion, 4:58.

"We wonder what was the least ocular aid used in witnessing this event. Our binocs had long since joined the Navy, or we would have tried. Jupiter was not visible in a 2-inch short-focus finder."

Also from Pittsburgh is a letter from Fred M. Garland, who reports on an observation of Mercury on April 13th. "I went up to Allegheny Observatory last night so that I could get above some of the haze here in Pittsburgh, in order to see Mercury if possible. About 7:00 E.S.T., I suddenly located the little planet with my naked eye. Zaccheus Daniel and I checked its position, so we were sure we weren't being fooled. Mercury disappeared in the clouded skies about 8 o'clock. It has been a long time since I saw the planet.

"It would be interesting to know how many amateurs saw Mercury this week. Leo Scanlon and I consider it rather a triumph to see Mercury from the north side of Pittsburgh, for from our location we must look across to the south and west, usually through a haze and smoky condition during these war times. In addition to this, there are now considerable bright electric lights burning in and around shipyards and factories, where night work is being done, so that some glare from those lights must be penetrated when observing bodies close to the horizon."

PHASES OF THE MOON

Full moon	June 6,	2:58 p.m.
Last quarter	June 13,	11:56 a.m.
New moon	June 20,	1:00 p.m.
First quarter	June 28,	1:27 p.m.

SPHEROGRAPHICAL NAVIGATION

(*Continued from page 17*)

thoroughly investigated the possibilities opened up by this new instrument. The possibilities are numerous and it appears that most of them are of a practical, not just theoretical, nature.

The method of obtaining celestial fixes by circles of position drawn directly on the sphere eliminates such computational means as H.O. 211, H.O. 214, and so on, and undoubtedly avoids a good many opportunities for error. The number of steps involved is certainly small, although the accuracy obtainable seems not to be large enough to employ the method for marine purposes. This is a small criticism since the method is ideal for aerial navigation. One definite advantage is its use in many problems of great circle sailing and the laying off of great circle courses on the Mercator chart. Of considerable value is the use of the method for determining fixes in the troublesome regions of the poles. In addition, such problems as preflight formation, time of transit of a star, times of sunrise and sunset, determination of altitudes and azimuths, and many others appear to be solvable with ease.

Perhaps one of the greatest advantages of the method is that you can **see** what you are doing — hence, tend to avoid many errors. The authors make no attempt to insist that the proposed method is superior to all others, but suggest it as an excellent alternative to other methods and frequently a superior one. The book also includes a discussion of such matters as co-ordinate systems, map projections, circles of position, time, and the **American Air Almanac.** A few useful tables are included in an appendix. The authors are to be congratulated on their efforts to pioneer and sponsor this new method.

E. G. EBBIGHAUSEN
Buhl Planetarium

★ ★

PLANETARIUM NOTES

Sky and Telescope **is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.**

★ **THE BUHL PLANETARIUM** presents, in *June*, STARS OF A SUMMER'S NIGHT.

Can you identify Vega, and Altair, and Antares — all among the brightest stars seen at this time of year? This sky show gives visitors simple methods for locating these and many other outstanding stars. We learn how to trace out easily the constellations of the Swan, the Scorpion, and the Archer, as well as lesser-known but equally interesting star groups of summer. After hearing some of the star legends of long ago, we turn to the amazing true stories of the stars which the scientist now can piece together from modern observations of the heavens.

★ **THE HAYDEN PLANETARIUM** presents, in *June*, THE SUN AND ECLIPSES. (See page 12.)

In *July*, SUMMER STARS. The warm, pleasant nights of summer mean "open house" for stargazers. The great curving hook of the Scorpion lies low over our southern horizon, while blue Vega rides high above us. This month we pursue our speaking acquaintance with the summer stars as viewed from both the Northern and the Southern Hemispheres. Of course, we shall discover, as we travel southward, why our summer stars are winter stars "down under."

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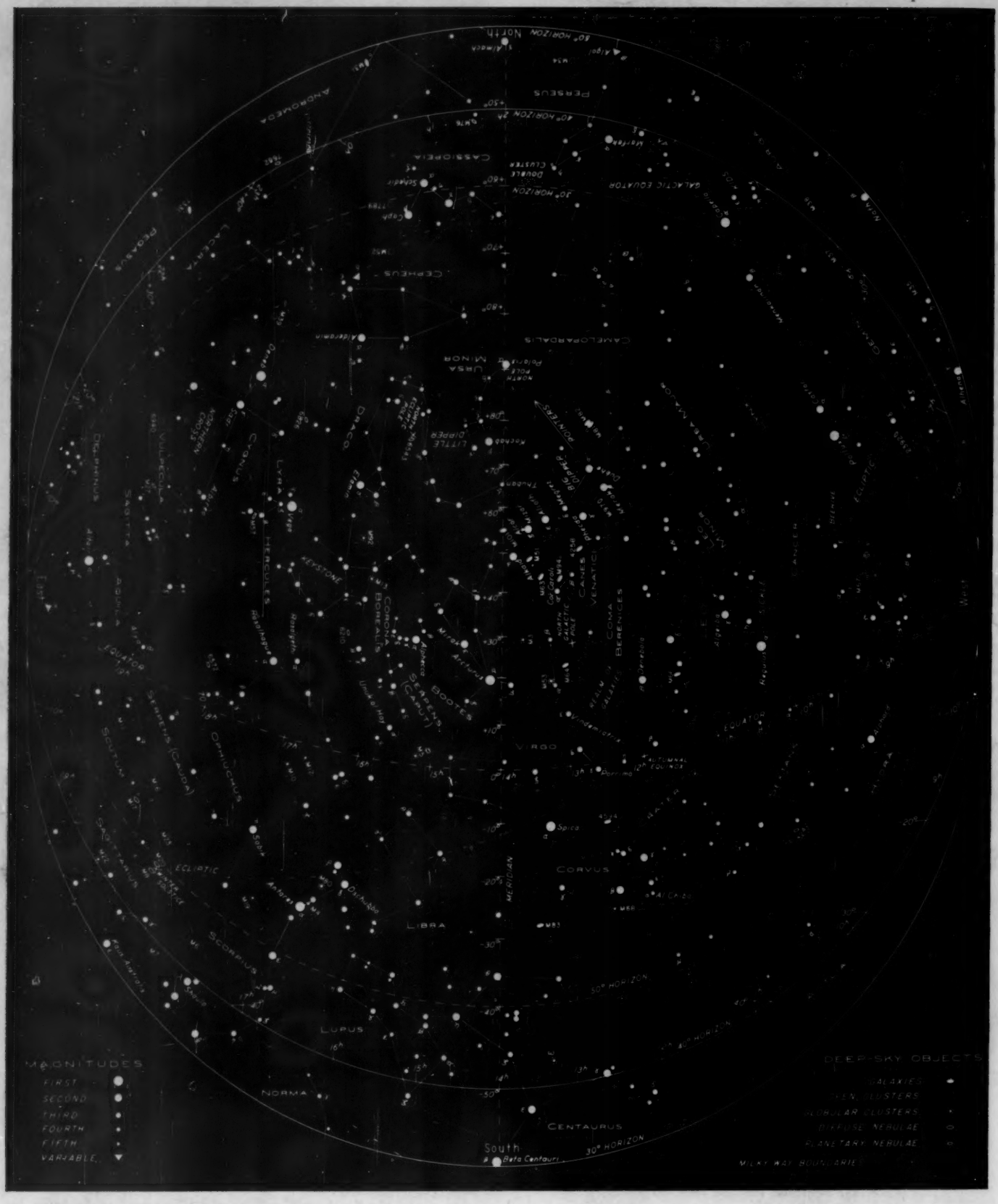
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Associate Curator*, Marian Lockwood; *Assistant Curator*, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.



DEEP-SKY WONDERS

AMONG marvels for observation in the June skies are the objects listed here. The informal descriptions portray appearance in common telescopes.

Ophiuchus. M12, $16^h\ 44^m.3$, —1° 51′; globular of 6th magnitude; larger, brighter, and less spherical than M10. M10, $16^h\ 54^m.3$, —4° 01′; globular of magnitude 5.4.

Serpens Caput. M5, $15^h\ 15^m.8$, +2° 17′; globular of 3.6 mag.; just visible to the naked eye; brighter and larger than famous M13 in Hercules.

Virgo. NGC 4594, $12^h\ 37^m.3$, —11° 21′; spiral of 8th mag., 7′ x 1′.5; handsome Sombrero, intrinsically brightest galaxy; black line across center; by amateurs, seen within a triangle of stars.

Cassiopeia. M52, $23^h\ 19^m.8$, +61° 03′; open cluster of 120 stars, most of them bright in amateur telescopes.

L. S. COPELAND

STARS FOR JUNE

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, withouf distortion. All co-ordinate lines are parts of circles.

A BOY in his father's spectacle-making shop around 1610 . . . two lenses and a tube . . . the result: the accidental discovery of the first compound microscope. Thus, does history record Zacharias Jansen's claim to fame.

Denied the honor of being discoverer of the telescope by the weight of evidence, his claim in the microscope controversy seems to be stronger than that of Galileo, his leading competitor.

One of Jansen's microscopes, presented to Austrian Archduke Albert, then supreme governor of Holland, has been variously described as six feet, two and a half feet, and one and one half feet long . . a tube of gilded brass supported by three dolphins . . . an ebony disc at the base on which minute objects were inspected from above.

Today, 334 years after Jansen's discovery, other men of vision are viewing minute objects and charting new courses in other lines of optical endeavor . . . using new lenses and prisms to fathom the depths of Nature's secrets. With these men in industry, education and the armed forces, Perkin-Elmer has been happy to work and plan . . . helping write new pages in optical history.

WHAT PERKIN-ELMER HAS DONE FOR OTHERS, IT CAN DO FOR YOU

PROBLEM: To prevent parallax from causing untrue readings on barometers.

SOLUTION: Perkin-Elmer engineered a special optical system which made every reading absolutely correct from every angle of vision.

If you're looking for an optical answer to a question of analysis, control or inspection . . . if you need a specific device for a known function, Perkin-Elmer can probably help you. Here, optical engineers, with a tradition of accuracy measured in millionths of an inch or of a circle, bow to none in ability to make custom-built instruments of the highest quality.

WHAT PERKIN-ELMER MAKES

Custom-built optical instruments for industrial analysis, control, and inspection.

New optical devices to solve specific problems.

Special elements such as fine lenses, prisms, mirrors, flats, photographic objectives, interferometer plates, retardation plates, Cornu prisms, Rochon prisms, and Nicol prisms.

Unusual optical parts worked from crystalline materials such as quartz, calcite, fluorite, lithium fluoride, sodium chloride, and potassium bromide.

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